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Monitoring and Modeling Analyses of the Kennecott Corporation Smelter in McGill, Nevada

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16. ABSTRACT

An independent assessment of the particulate control strategy for the Kennecott Copper Smelter in McGill, Nevada was conducted to support EPA Region IX in determining whether revisions to the EPA approved Nevada State Implementation Plan (SIP) represent an adequate level of control. The report presents a review of information submitted by the State of Nevada and the Kennecott Corporation regarding the air quality impact of emissions from the smelter; application of the Valley and Hydrodynamic Models to the smelter; and meteorological data from the National Weather Service at Yelland Field, Ely, Nevada. A detailed emission inventory of total suspended particulate (TSP) sources was developed for the area encompassing a 5 mile radius from the smelter to evaluate the air quality impacts of stack and fugitive particulate emission sources.

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MONITORING AND MODELING ANALYSES OF THE KENNECOTT CORPORATION SMELTER IN McGILL, NEVADA

by

PEDCo Environmental, Inc.
11499 Chester Road
Cincinnati, Ohio 45246

Contract No. 68-02-3173
Task No. 14

Project Officer

Linda Larson
Air Technical Branch

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IX
SAN FRANCISCO, CALIFORNIA 94105

March 1981

EXECUTIVE SUMMARY

At the request of Region IX of the Environmental Protection Agency (EPA), PEDCo Environmental, Inc., was hired to give an independent assessment and review of the technical aspects of the air quality analyses carried out at the Kennecott Smelter in McGill, Nevada.

The primary objectives of this study are listed below:

- To review the application of the Valley Model to the Kennecott smelter at McGill, Nevada.
- To review documents submitted by Kennecott Copper Corporation to the EPA regarding the air quality impact of emissions from the smelter.
- To develop an emission inventory of total suspended particulate (TSP) that encompasses a 5-mile radius from the smelter.
- To use dispersion modeling for determining the contributions of sources to any violation of TSP air quality standards.
- To apply simple rollback methods for estimating the extent of control necessary for reducing emissions from the main smelter stack in order to attain the primary and secondary TSP standards.

The main issue upon which all the above objectives focus is whether particulate emissions from the main stack or fugitive TSP emissions from the tailings pond are the principal contributor to measured violations of the National Ambient Air Quality Standard (NAAQS) for TSP. All available TSP air quality data collected

near the smelter were reviewed along with emission estimates for all sources, meteorological data, and previous modeling methodologies and results; however, it could not be determined whether the tailings pond or the main stack is the worst contributor. Under various worst-case emission and meteorological scenarios, either source can be shown to contribute the major portion of the TSP concentration at different receptors. Modeling was used to determine concentrations from the main stack over a 24-hour averaging period. The maximum impact on air quality was estimated to occur during stable atmospheric conditions coupled with light windspeeds from the west and northwest at plume height. Under these conditions, the plume disperses and travels toward the mountains to the east of the plant. Lower maximum concentrations from the main stack are estimated in the Steptoe Valley under very unstable, light-wind conditions. Emissions from the tailings pond have a maximum impact on air quality under condition of generally high windspeed, persistent wind direction, and near neutral atmospheric stability.

The latter conditions occur more frequently in the Steptoe Valley indicating that emissions from the tailings pond contribute more frequently to the measured TSP violations of the NAAQS in the valley than from the main stack. The supporting documentation, however, is somewhat inadequate to verify this conclusion. The dispersion modeling conducted by EPA, Kennecott, and PEDCo Environmental indicates no estimated violations of the

NAAQS on a 24-hour or annual average basis due to individual or combined emissions from the main stack and the tailings pond at current monitoring sites. When fugitive emissions from smelter processes, the smelter boiler, and miscellaneous TSP sources are included, however, some excursions of the TSP NAAQS are estimated to occur near monitor sites.

Thus, this analysis concludes that an inadequate demonstration (and therefore, data base) has been made to support promulgation of control measures only for the main stack at the McGill Smelter. A demonstration has not been made that is sufficiently convincing that TSP violations are caused solely by the windblown dust from the tailings pond. This analysis does indicate higher TSP concentrations when the smelter is operational than when it is not. This may be due to increased particulate emissions from the main stack, the smelter fugitive emissions, or both. Modeling results are inadequate, however, to clearly describe this phenomenon.

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SECTION 1

INTRODUCTION

Particulate emissions from the McGill smelter are 12 to 18 times the federally approved process limitations. Ambient TSP concentrations were measured at Site No. 29-0560-022, which is operated by the Department of Conservation and Natural Resources (DCNR), and at three semipermanent sites, which are operated by Kennecott. These measurements show violations of the 24-hour National Ambient Air Quality Standard (NAAQS) for total suspended particulate (TSP) in the vicinity of the plant. Air quality dispersion modeling conducted by Kennecott using the Valley Model[1] shows the potential for violation of the primary standards on nearby terrain based on particulate emissions from the main smelter alone, but not at current monitor sites. Kennecott, on the other hand, claims that the Valley Model overpredicts actual ambient TSP concentration and contends the violations of the NAAQS for TSP result from fugitive emissions from the tailings pond.

The purpose of this report is to review the modeling results and monitoring data provided by Kennecott, the DCNR, and the Environmental Protection Agency (EPA) to determine if an adequate data base can be found to substantiate and identify the source of

emissions that contributes to worst-case ambient TSP concentrations. This report also includes a revised particulate emission inventory that is used as input for subsequent modeling.

1.1 BACKGROUND

Kennecott Minerals Corporation (KMC) operates a primary copper facility in McGill, Nevada. The smelter is in the Steptoe Valley about 16 km to the north-northeast of Ely, Nevada. The Egan Range to the west and Duck Creek Range to the east rise 4000 ft above the valley floor at the plant site (see Figure 1-1). The main facility lies at the base of the eastern side of the valley with the tailings pond stretching almost all the way across the valley to the western piedmont and mountains. Predominant winds are from the south at an annual average speed of about 5 m/sec. Precipitation in the valley averages only about 10 to 11 inches per year, while surrounding mountaintops record higher average precipitation. The Steptoe Valley ranges in width from about 12 to 20 km. The valley width near the smelter is about 12 km and constricts the natural windflow. This constriction tends to cause a veering of the general wind directions measured at the Ely Airport located to the south-southwest compared with those measured just north of the plant site at the North Flat. The whole valley is characterized by lowlying scrub bushes and crusty surfaces with some farmland and pasture.

Valley floors in this region are about 6000 ft above sea level. This high elevation coupled with a clear, dry atmosphere

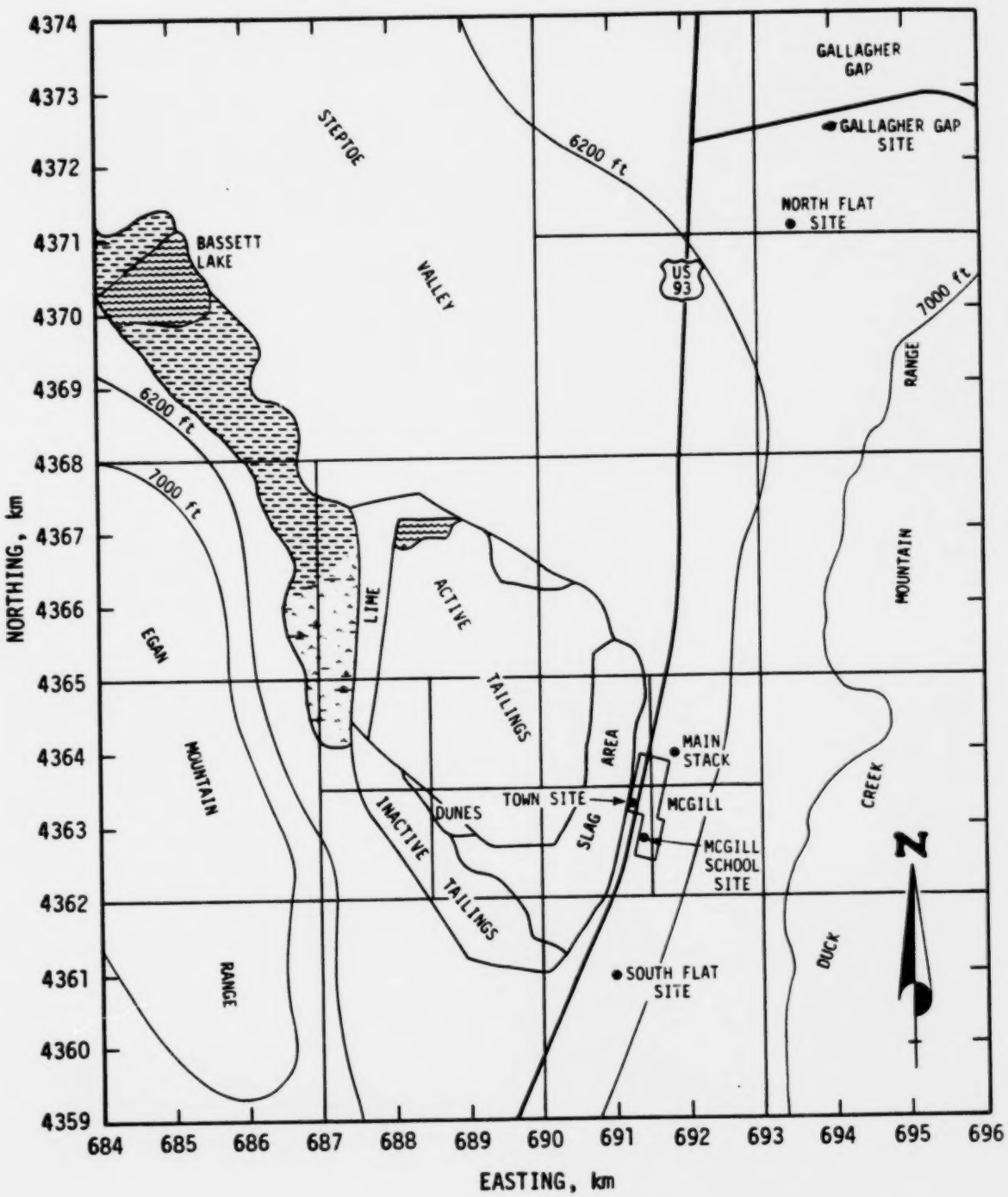

Figure 1-1. Major geographical features of the study area.

is conducive to sharp night-time radiation cooling that produces inversion conditions in the valleys. A very pronounced drainage wind sweeps down the valley in the early morning hours; under strong to medium surface heating by the sun, the inversions and drainage winds are generally dissipated by mid-morning. Gusty winds from the south-southwest often exceed 9 to 10 m sec^{-1} (15 to 16% of the time) and cause reentrainment of much of the surface particulates from the 3000-acre tailings pond.

The following primary sources of particulate emissions are attributable to the McGill smelter:

- Main stack

  Height: 229 m
  Diameter: 4.7 m
  Gas velocity: 20.4 m sec^{-1}
  Elevation: 6330 ft mean seal level (m.s.l.)
  Location: Universal Transverse Mercator (UTM) Coordinates
  N 4364450 m
  E 692000 m
  Maximum hourly TSP emissions ≈2100 lb/h

- Boiler stack

  Height: 32 m
  Diameter: 2.1 m
  Gas velocity: 2.1 m sec^{-1}
  Elevation: 6305 m.s.l.
  Location: UTM Coordinates
  N 4364250 m
  E 691940 m
  Maximum hourly TSP emissions ≈120 lb/h

- Fugitive emissions from smelter operations

  Vented process dust
  Hauling and dumping input materials
  Road dust
  Located near main stack (center coordinates same)
  Estimated by Kennecott to be 35 percent of main stack emissions

- Fugitive emissions from tailings pond

  West of main facility 1 km
  Over 3000 acres, 2100 acres active
  Many small particles (<10 μm) subject to retrainment by wind erosion
  Some areas controlled by:
    Water
    Furrowing and water
    Vegetation
    Crusting
  UTM Coordinates: N 4364700 m
  (center of area) E 689500 m
  Emissions vary (see Sections 2 and 5)

The Kennecott copper plant consists of two reverberatory furnaces, one of which is shut down, and four Peirce-Smith Converters, one of which is not used. Average production rates are as follows:

- Blister copper capacity, 136 tons/day.
- Concentrate processed, 544 tons/day.

The Nevada Department of Conservation and Natural Resources operates a TSP high-volume sampler every sixth day at a site near downtown McGill. The monitor is situated on the roof of the McGill elementary school, about 1.6 km from the main stack. Previous modeling experience and modeling guidance (e.g., Turner 1970) indicate that emissions from a stack as tall as the main stack will generally have only a minimal impact on a receptor as close as the McGill School except under extreme conditions (i.e., very unstable atmospheric conditions with windspeeds less than 2 to 3 m sec^{-1}). Kennecott operates three TSP high-volume samplers on approximately the same schedule as those on the State site. Figure 1-1 shows the approximate location of all sites.

1.2 SMELTER SIP HISTORY

On May 13, 1980, representatives of Kennecott Corporation and the EPA met in Washington, D.C., to discuss possible solutions to the issues separating the two regarding the air quality impact of the McGill Smelter. The EPA's presentation included a chronological history of the State Implementation Plan for the McGill Smelter. Table 1-1 summarizes EPA's chronological listing. Table 1-2 highlights the proposed revisions to the Nevada SIP of October 7, 1976, and September 18, 1979. Finally, Table 1-3 summarizes the deficiencies noted by EPA concerning the proposed September 18, 1979, revisions. Based on a review of these tables, it is evident that EPA has concluded that KMC's strategy and Nevada's proposed relaxation of the approved State Implementation Plan (SIP) are inadequate to maintain the NAAQS. In their May 13, 1980, bid for reconsideration of EPA's promulgation of the approved SIP, Kennecott also asked EPA to consider the economic impact on McGill if the smelter were forced to close. No settlement has been agreed upon to date by Kennecott and EPA.

The following sections will review and verify the application of the Valley Model (Section 2), review North American Weather Consultants Study (Section 3), review Kennecott's comments on EPA 110g action, September 21, 1979 (Section 4), review Hydrodynamic Model (Section 5), describe the TSP emission inventory and subsequent modeling results (Section 6), and describe an updated analysis of monitored data (Section 7).

TABLE 1-1. CHRONOLOGICAL LISTING OF SIP STRATEGIES TO CONTROL TSP AT THE McGILL COPPER SMELTER

5/31/72	Disapproval of the control strategy portion of Nevada's plan for failure to demonstrate attainment and maintenance of both primary and secondary particulate standards in the Nevada Intrastate AQCR. Article 7.2 (Process Weight Regulation) was approved.
10/7/76	Nevada submits a revision to Article 7.2.
3/15/79	EPA proposes to disapprove the relaxation of Article 7.2.
7/30/79	KMC submits control strategy to EPA.
8/7/79	KMC submits revised strategy to EPA.
8/24/79	Governor of Nevada issues a 110(g) suspension to suspend Article 7.2.
9/13/79	EPA disapproves the 110(g) suspension for failure to demonstrate that the SIP revision, upon which the suspension was issued, would protect ambient standards.
9/18/79	Governor of Nevada submits a revision to Article 7.2, issues a 110(g) suspension, and grants a 1-year variance.
10/17/79	EPA disapproves the 110(g) suspension since the suspension was premature.
2/6/80	EPA disapproves the 10/7/76 TSP SIP revision.

TABLE 1-2. NEVADA SIP REVISIONS

A. HIGHLIGHTS OF THE 10/7/76 REVISION

Specifies 1300 lb/h value averaged over 24 hours.

Regulates only solid particulate matter, but does not define solid particulate matter.

No control strategy was submitted with the revision to Article 7.2.

No compliance test method is specified.

Included a variance for 1 year (no action taken).

SO_2 regulation deleted (EPA has deferred action on this).

B. HIGHLIGHTS OF THE 9/18/79 REVISION

1300 lb/h limit on solid particulate matter averaged over 24 hours.

2100 lb/h limit on total particulate matter averaged over 24 hours as measured by EPA Method 5.

Includes a 1 year variance.

Includes a revision to the SO_2 regulation (Article 8).

TABLE 1-3. DEFICIENCIES OF 9/18/79 REVISION

Emission inventory is not accurate.
Air quality design value is incorrect.
750-ft stack not demonstrated to be GEP.
Control measures relied upon for the emission reductions are not legally enforceable.
No compliance schedules have been submitted.
Solid particulate matter is not defined (same deficiency that existed with the previous submission).
Use of Method 5 to determine compliance with a limit averaged over a 24-hour period poses practical difficulties.
Attainment has not been demonstrated.

REFERENCE FOR SECTION 1

1. Burt, E. W. Valley Model User's Guide. EPA-450/2-77-018, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. September 1977.

SECTION 2

REVIEW OF THE VALLEY MODEL APPLICATIONS

On July 30, 1979, Kennecott submitted a report to EPA entitled "An Analysis of Kennecott's Particulate Control Strategy at the McGill, Nevada, Operations."[1] The purpose of this report was to demonstrate the following:

- That EPA could relax the particulate emission limitations applied to the smelter stack without risking violations of the ambient TSP standards.
- That control of fugitive emissions from the tailings pond would result in the attainment of the TSP standards.

The EPA requested further information and documentation regarding a detailed emission inventory, an analysis of compliance costs, and dispersion model estimates of ambient TSP concentrations in areas where actual measurements have not been made.

Kennecott submitted an additional control strategy package on August 7, 1979, showing attainment of the NAAQS for TSP.[2] At this point, EPA disapproved of using the Air Quality Display Model[3] for estimating TSP annual averages on the basis that the model was designed for flat terrain and therefore results obtained near the McGill Smelter would be inappropriate. For short-term estimates of maximum concentration, Kennecott primarily used the Hydrodynamic Model.[4] The EPA also dismissed this model on the

basis of too little documentation and inadequate treatment of the complex flows that occur in and around complex terrain. At EPA's request, Kennecott used the Valley Model to estimate concentrations from the main stack, the smelter process fugitives, and the tailings pond.[5] On August 10, 1979, Kennecott submitted to EPA a revised control strategy that essentially summarized the results of applying the Valley Model. Both annual and 24-hour violations of the TSP NAAQS were estimated for the Steptoe Valley and for nearby terrain.

Throughout the various submissions to EPA over the past year, Kennecott has maintained that the use of the Valley Model for regulatory purposes was inappropriate because of simplistic model assumptions and inadequate validation, especially at the McGill Smelter. The EPA, however, points out that no other models have been demonstrated to perform at the McGill Smelter and that the Valley Model has been used correctly, i.e., as a screening methodology to discern potential smelter impacts.

2.1 APPROPRIATENESS OF THE VALLEY MODEL

2.1.1 Past Guidance

In choosing the Valley Model for analyzing the potential impact of particulate emissions from the smelter on ambient air quality near the McGill Copper Smelter, Region IX was following the policy established in previous EPA decisions. In the Guideline on Air Quality Models,[6] two levels of modeling are considered: simple and refined. As stated in the Guideline:

> The first level consists of general, relatively simple estimation techniques that provide conservative estimates of the air quality impact of a specific source, or source category. The purpose of such techniques is to eliminate from further consideration those sources that clearly will not cause or contribute to ambient concentrations in excess of NAAQS or allowable concentration increments. Conversely, these techniques can be used to identify those control strategies that have the potential to meet NAAQS and allowable increments.

The Guideline, however, does not identify any refined techniques that are applicable to complex terrain. The Regional Workshops on Air Quality Modeling: A Summary Report[7] concludes that:

> ...an inadequate technical basis [exists] for recommending refined models that can be generally used in complex terrain situations. A need obviously exists for a complete mathematical description of the physical processes involved. It is, therefore, necessary to first require the application of conservative screening techniques to determine the impact of sources in complex terrain. If such techniques show a potential problem, it is incumbent upon the source operator to develop a specific on-site data base for use in a refined model that has been shown to provide satisfactory estimates in a similar situation.

The Summary Report[7] continues:

> The screening technique recommended for use in complex terrain situations is the Valley Model. When the applicant is planning to operate the source during times of stable atmospheric flows, the Valley Model should be used with the following worst case meteorological assumptions: (1) P-G [Pasquill-Gifford] stability of "F"; (2) wind speed of 2.5 m/s; and (3) six hours of occurrence. The use of "F" stability in Valley screening analyses has been challenged as overly conservative because there may be increased mechanical turbulence in rough terrain which the Pasquill-Gifford parameters do not consider, and at times the use of "F" stability in the Valley Model has significantly overestimated observed concentrations. However, there is not adequate justification for making such a change to the screening technique since (1) there are cases where Valley with "F" stability has proven to be a good predictor of worst case concentrations, and (2) in some of the field

> studies performed in complex terrain the stability of the atmosphere has been measured to be more stable than "F" stability.

Based on EPA guidelines, the Valley Model is acceptable as a screening tool for estimating ambient concentrations under worst-case meteorological and emission scenarios for sources located in complex terrain. In attempting to apply the Hydrodynamic Model, Kennecott did not develop an acceptable onsite data base (especially for the mountains to the east), nor did they obtain approval from EPA to use the model. The EPA's disapproval stemmed from a number of factors (discussed in Section 2), especially due to the Hydrodynamic Model's tendency to underpredict concentrations in complex terrain. Finally, since the Hydrodynamic Model was disapproved, the Valley Model was the only method available. The Summary Report[7] reiterates the position of the Guideline:[6]

> In the absence of other models shown to be more appropriate, the Valley Model is acceptable as the basis for selecting emission limitations in complex terrain situations.

This guideline indicates that an alternative model must be technically acceptable to EPA and be supported by a strong data base. If the proposed model is found to be unacceptable based on criteria in the EPA guidelines, the Valley Model should be used even though it may have no supporting data base in the vicinity and involves very simplistic treatment of plume flow about the terrain. Past studies summarized below indicate the performance of the Valley Model in complex terrain.

2.1.2 Previous Valley Model Applications

In a 1977 paper, E. Burt and H. Slater[8] compared highest and second-highest concentrations of SO_2 observed over a 24-hour period[8] at sites on elevated terrain near large emission sources. All sites were at heights where the maximum air quality impact was expected to occur. The paper indicates that at four of the six sites the Valley Model estimates maximum 24-hour SO_2 concentrations that are within a factor of two of the second-highest observations (see Table 2-1). The paper also indicates, however, that two of the sites were over 20 km downwind of the source, and the estimated and measured concentrations at these distances ranged from 15 to 36 $\mu g/m^3$ of SO_2. Because no models in flat or complex terrain are expected to estimate dispersion at this distance and these estimates are well below the 24-hour SO_2 NAAQS (365 $\mu g/m^3$), they are not the best indicators of plume impact on nearby terrain. The most similar site in terms of source/receptor distance to the McGill Smelter is the Jones Ranch receptor, which is 2.9 km from the Miami Smelter. The Valley Model overestimated measured maximum 24-hour terrain impacts by a factor of 4.2 in 1974 and 3.2 in 1975.

A monitoring and modeling analysis undertaken by Ashland Oil, Inc., and Systems Application, Inc.,[9] was designed to provide a data base for evaluating the performance of the Valley Model. On a case-by-case basis, the Valley Model performed very poorly in estimating observed SO_2 concentrations, ranging from

TABLE 2-1. THE ESTIMATED AND THE HIGHEST AND SECOND HIGHEST OBSERVED 24-H SO_2 CONCENTRATIONS IN THE VICINITY OF LARGE SOURCES LOCATED IN COMPLEX TERRAIN

Site	Source	Distance from the site to the source, km	Concentration, $\mu g/m^3$ except as noted			
			Period	Estimated	Observed	
					Maximum	Second highest
Crusher	Garfield Smelter, Utah	6.4	4/15/73-1/31/75	2480	2564	2473
			2/1/74-1/31/75	2480	6130	3130
Lower Lake Pt.	Garfield Smelter, Utah	4.5	3/8/75-12/16/75	1.18 ppm	2.66 ppm	1.20 ppm
			1/1-25/76	1.18 ppm	2.71 ppm	2.14 ppm
No. 106	Navajo Gen Stn, Arizona	22.8	10/1/74-2/17/75	36	32	19
No. 107	Navajo Gen Stn, Arizona	23.2	10/1/74-2/17/75	25	30	15
Phelps Mine	Morenci Smelter, Arizona	4.7	1975	15490	2547	2416
Jones Ranch	Miami Smelter, Arizona	2.9	1974	8610	2042	1760
			1975	8610	2642	1548

100 times too low to 5 times too high. When the highest concentration estimated (1510 $\mu g/m^3$) is compared with the highest observed (1131 $\mu g/m^3$), however, the model estimates are about 1.4 times higher. Also of note is that the maximum concentration actually occurred at a totally different receptor location from that predicted by the model. Thus, had Ashland Oil conformed with the derived emission limitations of the Valley Model, the NAAQS may not have been violated to the extent measured. This assumption is only conjecture, however. The alternative monitoring methodology employed by Ashland Oil verified that violations of the 24-hour standards do occur but not to the extent estimated by the Valley Model. Ashland was able to refine the air quality analysis by implementing a statistical methodology utilizing available meteorological, emissions, and monitoring data.

Lee[10] compared selected results of the Valley Model with observed concentrations. Reference is made to the evaluation by Lantz, Hoffnogle, and Pahwa[11] in which estimated and observed pollutant concentrations were noted for the Navajo Power Plant (Arizona) for stable cases (same data as used by Burt and Slater[8]). Only the ratio of estimated to observed maximum 1-hour concentrations was included in the analysis. For the Navajo study, the ratio of estimated to observed ranged from 0.34 to 2.6. No 24-hour comparisons were made.

Slowick and Pica[12] compared the Valley Model with observed concentrations at a sample site in Laurel Ridge, Pennsylvania, near the Conemaugh Generating Station. Comparisons between

estimated and observed 1-hour SO_2 concentrations were made over a period of 1 year. Researchers found that the ratio of estimated to observed maximum 1-hour concentration was about 40 for the highest concentration.

The evaluations of the Valley Model in these studies tend to agree with Burt and Slater's 1977 summary[8] which indicates that (1) for estimating second highest 24-hour concentrations in mountainous terrain, the Valley Model is usually within a factor of two, and (2) the model is inappropriate for day-by-day or hour-by-hour comparisons. In summary, several concerns have reappeared in the evaluations of the Valley Model. These include plume passage through mountainous terrain, arbitrary placement of the plume up to 10 meters from the terrain, and an inadequate description of the windflow in complex terrain. These technical inadequacies are noted in the Valley Model user's guide, and are recognized by the EPA and the general technical community as deficiencies of the model for simulating physical reality. The model has shown to be conservative and straightforward to apply, and is thus maintained by EPA as a screening tool and an acceptable modeling technique for complex terrain.

2.1.3 Application of the Valley Model at the McGill Smelter

2.1.3.1 Overview--

The EPA and Kennecott initiated modeling of both the annual average and 24-hour average TSP concentrations at the McGill

Smelter. In model applications conducted with National Weather Service (NWS) stability-wind rose data (STAR) from the Ely Airport, EPA found that concentrations at 13 receptors were estimated to violate the annual NAAQS (75 $\mu g/m^3$), with a maximum concentration of 284 $\mu g/m^3$. At 12 of the 13 receptors, the violations were caused by fugitive emissions from the smelter. At the remaining receptor, emissions from both the main stack and the smelter contributed to the violation. Measured violations of the annual NAAQS do not occur at the monitor sites as predicted by the Valley Model. Concentrations in excess of the NAAQS are estimated because emissions from all sources are much higher than those that actually occurred annually.

Results of the 24-hour average modeling conducted by Kennecott show that emissions from the main stack alone violated the primary TSP standard of 260 $\mu g/m^3$ under E and F stability conditions. These critical receptors were located in the eastern mountains 1.5 km from the plant. Emissions from the main stack are also estimated to violate secondary TSP standards under A stability at various sites in the valley. Tables 2-2 through 2-5 show the estimated concentrations caused by emissions from the main stack and fugitive emissions from the smelter and tailings pond for each wind direction and stability condition, regardless of downwind direction. No violations were estimated to have been caused by fugitive emissions from the tailings pond (see Table 2-3).

TABLE 2-2. 24-HOUR PREDICTED TSP CONCENTRATIONS ($\mu g/m^3$) NEAR McGILL, NEVADA MAIN STACK CONTRIBUTION

Radial direction from smelter	Stability Class					
	A	B	C	D	E	F
N	190*	24	11	0.8	0	0
NNE	175*	24	11	0.8	0	0
NE	142	24	11	0.8	241*	380*
ENE	201*	24	11	0.8	416*	633*
E	190*	24	11	0.8	781*	1760*
ESE	201*	24	11	0.8	523*	1039*
SE	142	24	11	0.8	566*	1381*
SSE	175*	24	11	0.8	582*	897*
S	190*	24	11	0.8	171*	335*
SSW	136	24	11	0.8	0	0
SW	194*	24	11	0.8	0	0
WSW	201*	24	11	0.8	0	0
W	190*	24	11	0.8	0	0
WNW	201*	24	11	0.8	0	0
NW	194*	24	11	0.8	0	0
NNW	136	24	11	0.8	0	0

These 24-hour TSP concentrations were predicted by the Valley Model, based on TSP emissions of 2100 lb/h from the main stack at Kennecott. For each stability class, the highest concentration ($\mu g/m^3$) along each radial is shown. Predicted violations of the 24-hour NAAQS, both primary (260 $\mu g/m^3$) and secondary (150 $\mu g/m^3$) standards, are shown with an asterisk. These concentrations ignore any background contribution.

SOURCE: Analysis of the Kennecott Copper, McGill, Nevada Particulate Control Strategy, EPA Region memorandum dated August 20, 1979.

TABLE 2-3. 24-HOUR PREDICTED TSP CONCENTRATIONS ($\mu g/m^3$) NEAR McGILL, NEVADA FUGITIVE SMELTER EMISSIONS

Radial direction from smelter	Stability Class					
	A	B	C	D	E	F
N	61	75	83	6	39	54
NNE	56	78	85	6	363*	435*
NE	60	81	86	7	687*	850*
ENE	44	66	75	5	542*	714*
E	51	75	83	6	589*	758*
ESE	44	66	74	5	481*	633*
SE	61	81	86	7	614*	758*
SSE	56	78	85	6	633*	798*
S	62	75	83	6	635*	818*
SSW	92	90	88	10	316*	397*
SW	60	57	68	5	41	16
WSW	44	66	75	5	13	1
W	52	75	83	6	21	6
WNW	44	66	68	5	10	1
NW	59	56	68	5	11	1
NNW	91	90	87	10	18	4

These 24-hour TSP concentrations were predicted by the Valley Model, based on TSP emissions of 735 lb/h (i.e., 35% of the main stack emissions). For each stability class, the highest concentration ($\mu g/m^3$) along each radial is shown. Predicted violations of the 24-hour NAAQS, both primary (260 $\mu g/m^3$) and secondary (150 $\mu g/m^3$) standards, are shown with an asterisk. These concentrations ignore any background contribution.

SOURCE: Analysis of the Kennecott Copper, McGill, Nevada Particulate Control Strategy, EPA Region memorandum dated August 20, 1979.

TABLE 2-4. 24-HOUR PREDICTED TSP CONCENTRATIONS ($\mu g/m^3$) NEAR McGILL, NEVADA TAILINGS POND SOURCE

Radial direction from smelter	Stability Class					
	A	B	C	D	E	F
N	0	0.8	2	36.9	0	0
NNE	0	0.8	2	37.1	0	0
NE	0	0.8	2	41.9	0	0
ENE	0	0.8	2	31.8	0	0
E	0	0.9	2	38.5	0	0
ESE	0	0.9	2	30.8	0	0
SE	0	0.8	2	40.4	0	0
SSE	0	0.8	2	37.7	0	0
S	0	0.8	2	36.7	0	0
SSW	0	0.7	2	43.0	0	0
SW	0	0.8	2	48.6	0	0
WSW	0	0.8	2	42.4	0	0
W	0	0.9	2	51.8	0	0
WNW	0	0.8	2	39.5	0	0
NW	0	0.8	2	50.4	0	0
NNW	0	0.8	2	42.1	0	0

These 24-hour concentrations were predicted by the Valley Model, based on TSP emissions (emissions vary with wind speed and were estimated from measurements at 10 mph and extrapolated to 30 mph) from the tailings pond at Kennecott. For each stability class, the highest concentration ($\mu g/m^3$) along each radial is shown. No violations of the 24-hour TSP NAAQS are predicted. These concentration ignore any background contribution.

SOURCE: Analysis of the Kennecott Copper, McGill, Nevada Particulate Control Strategy, EPA Region memorandum dated August 20, 1979.

TABLE 2-5. 24-HOUR PREDICTED TSP CONCENTRATIONS ($\mu g/m^3$) NEAR McGill, NEVADA
SUM OF STACK AND FUGITIVES AND TAILINGS POND AND BACKGROUND

Radial direction from smelter	Stability Class					
	A	B	C	D	E	F
N	266*	100	108	62	64	79
NNE	256*	103	110	62	388*	460*
NE	228*	106	112	67	712*	875*
ENE	270*	91	101	58	567*	740*
E	266*	100	109	60	871*	1888*
ESE	269*	91	100	57	569*	1167*
SE	228	106	111	65	657*	1510*
SSE	256	103	110	63	658*	965*
S	267*	100	108	62	660*	841*
SSW	190*	115	113	68	341*	422*
SW	258*	82	93	74	66	41
WSW	270*	91	100	68	38	26
W	267*	100	108	83	46	31
WNW	270*	91	100	65	35	26
NW	258*	81	93	75	36	26
NNW	190*	115	112	67	43	32

These 24-hour TSP concentrations were predicted by the Valley Model. For each stability class, the highest concentration ($\mu g/m^3$) along each radial is shown. Predicted violations of the 24-hour NAAQS, both primary (260 $\mu g/m^3$) and secondary (150 $\mu g/m^3$) standards, are shown with an asterisk. These concentrations ignore any background contribution.

SOURCE: Analysis of the Kennecott Copper, McGill, Nevada Particulate Control Strategy, EPA Region memorandum dated August 20, 1979.

2.1.3.2 Model Inputs--

Kennecott provided emission estimates and stack parameters for modeling at the McGill Smelter. Section 1 describes all the stack and fugitive source parameters. Previous source testing data for the main stack were used to estimate the TSP emissions. Kennecott estimated the maximum TSP emissions to be 265 g/s (2100 lb/h). Fugitive emissions from the smelter complex were estimated to be about 35 percent of the main stack emissions, or 92.7 g/s (735 lb/h). The rate of emissions from the tailings pond was calculated by measuring the TSP very near the pond at a windspeed of 10 m/s, by estimating the plume height and width, and by back-calculating via Gaussian assumptions. At 4.47 m/s (10 mph), the emission rate is estimated to be 16.38 g/s (130 lb/h) and at 13.4 m/s (30 mph), 1261 g/s (10,000 lb/h) (Kennecott extrapolated results). Table 2-6 presents emission factors used in the EPA and Kennecott 24-h Valley modeling. The factors are broken down according to stability and windspeed class. The fugitive emission factors are slightly less than those calculated by using the 735 lb/h rate. Emissions factors for B stability at a windspeed of 4.47 m/s (10 mph) are assumed to be the ones Kennecott used for their annual average estimates.

TABLE 2-6. EMISSION FACTORS USED BY EPA AND KENNECOTT
(g/s except as noted)

Stability class Windspeed, m/s	A 2.0	B 4.47	C 5.0	D 13.41	E 2.4	F 2.5
Emission sources						
Main stack	264.0	264.0	264.0	264.0	264.0	264.0
Smelter	90.21	90.21	90.21	90.21	90.21	90.21
Tailings	0.0	16.38	28.38	1261.0	0.0	0.0

Other inputs for the Valley Model include the receptor grid and meteorological data base for determining the impact of the worst-case condition. A simplified model (PTMAX[13]) was used as a screening procedure to locate receptors at the points of maximum concentration under the expected worst-case conditions in regard to emissions from the main stack (i.e., F stability and 2.5 m/s winds). Under these conditions, the final plume rise from the main stack was about 340 m (1130 ft), which was added to the stack base elevation (6330 m.s.l.). Under E and F stabilities, the plume was expected to disperse very little over the first few kilometers of downwind travel and thus have an impact only on nearby terrain at this height. The maximum concentration was estimated 1.5 km due east of the plant at an elevation of 7450 ft m.s.l. After this location is determined for the Valley Model, other receptors are locked into various preassigned positions in approximate radials ranging from about 0.7 to 6 km around the plant. Elevations are input for each receptor and source. The main stack is situated at the center of the coordinate system and is treated as a point source. Fugitive emissions from the smelter are treated as a square (305-m) area source centered on the coordinate system, with a fixed release height of 45 m. The tailings pond is a large square area source (≈2900 m on a side) situated 3 km to the west with a 15-m fixed-release height. In all cases in the Valley Model, area source dispersion is treated as if the plume is terrain-following, i.e., is located in flat terrain.

National Weather Service data from Ely, Nevada, in the STAR format were used to estimate the annual average concentrations 1973 to 1976. Annual average temperatures, pressures, and mixing heights are not specified in any of the EPA or Kennecott reports submitted to PEDCo. Short-term modeling estimates of these parameters found in EPA files are input as conservative annual meteorological data.

For the 24-hour analyses, the Valley Model guidance is followed in selecting meteorological parameters for the worst case, i.e., F stability, 2.5-m/s winds from the west toward the mountains. Table 2-6 summarizes other stabilities and associated worst-case windspeeds used in this analysis. The average monthly high temperature is estimated to be 288K (59°F), and the worst-case daily mixing height, 500 m. In addition to the grid of receptors just mentioned, a grid out to about 25 km is also used for the annual average estimates to prevent the occurrence of significant impacts further downwind.

2.1.3.3 Model Assumptions--

The following basic assumptions of the Valley Model were used in this analysis: the main stack gases have buoyancy and rise beyond the height of the physical stack height; area sources are treated as if they are located in flat terrain; stack sources may impact on nearby mountains; and source contributions to receptors are additive. Application of the Valley Model for 24-hour average concentration estimates also assumes that the

meteorological conditions will occur for at least 6 hours. Since no onsite meteorological data are available for the 300-m level (i.e., above the ground), the assumption is made that worst-case meteorology does occur or can occur at sometime over a 1-year period. (See Section 2.2.3.)

2.2 VERIFICATION OF THE VALLEY MODELING RESULTS

2.2.1 Overview

PEDCo was able to verify most of the 24-hour TSP concentration estimates obtained by EPA and Kennecott. Concentrations similar to previous Valley simulations were obtained through the use of like parameters, sources, meteorology, and model options (see Appendix A). Since PEDCo performed an independent screening analysis of the main stack and set up a receptor grid based on this analysis, the receptor grid is slightly different. The key feature of EPA's grid, however, was verified: the maximum impact on air quality is expected to take place in the mountains to the east of the plant at final plume height under F stability and 2.5 m/s windspeed.

2.2.2 PEDCo Verification

In order to test the calculations obtained by EPA and Kennecott in previous Valley Model applications, PEDCo obtained all input data as described in Section 2.1.3. A slightly different receptor grid is based on input from an independent screening and worst-case impact analysis. Emissions from the

main stack are estimated to have the greatest impact 1.61 km to the southeast (135 degrees) of the smelter. Even though the grid spacing of the receptors is slightly different, PEDCo's analysis results in concentration estimates almost identical to those presented in Tables 2-2 through 2-5. The minor differences between the results reported probably arise from subjective readings of topographical maps, variations in distance from the plant, and different screening results. Therefore, using essentially identical inputs to the Valley Model, PEDCo reproduced the TSP estimates obtained by EPA and Kennecott.

2.2.3 Update and Revision to Smelter Modeling

Some changes and refinements in emission parameters and source characterization results were added to the base case Valley results described in the previous sections. After previous Method 5 stack data on emissions from the smelter main stack were reviewed, the following changes were implemented:

Main stack - Exit velocity changed from 20.4 to 21.2 m/s
Main stack - Emissions reduced from 2100 to 2055 lb/h
Smelter fugitives - Emissions reduced from 735 to 710 lb/h

The only meteorological parameters changed were the 24-hour average temperature (from 288 to 290K) and the windspeed associated with a worst-case impact for A stability (based on PEDCo's PTMAX screening analysis of the main stack, the change was from 2.5 to 2.0 m/s). For the main stack, the screening analysis also indicated windspeeds of 5, 7, and 10 m/s as critical for B, C,

and D stabilities, respectively; however, these values are pre-empted because the only tailings pond emission factors available are for windspeeds of 4.47, 5.0, and 10.0 m/s.

Based on these revised parameters, some slightly modified tailings pond coordinates, and the independently derived receptor grid, the Valley Model was rerun for both the annual and 24-hour concentration estimates. Also, for the annual average simulations a larger grid of receptors was again included in a separate run. The maximum concentration from this latter large grid analysis is 50 $\mu g/m^3$ at about 5 km to the north-northeast of the plant. Since the smaller grid covers this region, no further results of this large-scale analysis will be discussed.

On the small grid, 14 violations of the annual average primary NAAQS (75 $\mu g/m^3$) are estimated. The arithmetically averaged Valley Model estimates must be compared with the NAAQS geometric mean. If a standard geometric deviation of 1.6[14] is assumed and the distribution of all concentrations is assumed to be log-normal, the following relationship from Larsen[15] may be used for the conversion from a geometric standard to an arithmetic standard:

$$m = mg\ [\exp\ (0.6\ \ln^2 sg)]$$

where
- m = the arithmetic mean NAAQS
- mg = 75 $\mu g/m^3$
- sg = 1.60 (average of several stations in nearby Utah counties)[14]

Thus, the standard may now be expressed as 84 $\mu g/m^3$, and one potential violation of the NAAQS is eliminated. One of the remaining 13 may be attributed to the main stack (72 percent of total). The 13 receptors are located as follows: 1 is to the southeast at 1.6 km from the main stack (at the point the main stack is expected to have maximum impact for 24-hour estimates), 9 are situated clockwise from the north to south at 0.6 to 0.9 km, 2 are located to the north-northeast at 1.3 km, and 1 is located northeast at 1.6 km (in the valley). No monitors are located at any of these sites. Estimated annual TSP concentrations recorded at 12 of the receptors range from 88 to 160 $\mu g/m^3$; the maximum estimate of 353 $\mu g/m^3$ was recorded at the remaining receptor, 0.67 km to the northeast of the plant. As with the previous analysis, these estimates are conservative since short-term particulate emissions are used rather than annual averages.

For short-term 24-hour concentrations, the Valley Model is used to estimate concentrations from the main stack, the smelter fugitives, and the tailings pond for stabilities A through F. Tables 2-7 through 2-10 summarize the results of these calculations. Maximum concentrations are presented for each wind direction and stability regardless of downwind distance. For estimates in which B, C, and D stability classes were used, little difference is detected in estimates for various wind directions and receptors; thus, only the four cardinal directions or a few other receptors are displayed. No violations of the primary NAAQS of 260 $\mu g/m^3$ are noted for stabilities A through D; although

TABLE 2-7. UPDATED MAXIMUM 24-HOUR TSP CONCENTRATIONS CAUSED BY EMISSIONS FROM THE MAIN STACK, ($\mu g/m^3$ except as noted)

Stability class Windspeed, m/s	A 2.5	B[a] 4.47	C[a] 5	D[a] 13.41	E 2.5	F 2.5
Radial direction from smelter						
N	128	24	10	0.8	0	0
NNE	118				0	0
NE	99				276	434
ENE	147				565	864
E	128	24	10	0.8	1214	1762
ESE	147				607	963
SE	99				885	1789
SSE	118				640	976
S	128	24	10	0.8	140	265
SSW	118				0	0
SW	160				0	0
WSW	147				0	0
W	128	24	10	0.8	0	0
WNW	147				0	0
NW	160				0	0
NNW	118				0	0

[a] B, C, and D stabilities were only partially modeled since concentrations appeared to be independent of wind direction.

TABLE 2-8. UPDATED MAXIMUM 24-HOUR TSP CONCENTRATIONS CAUSED BY EMISSIONS FROM THE SMELTER FUGITIVES, ($\mu g/m^3$ except as noted)

Stability class Wind speed, m/s	A 2.5	B[a] 4.47	C[a] 5	D[a] 13.41	E 2.5	F 2.5
Radial direction from smelter						
N	47	81	88	8	33	19
NNE	50				169	271
NE	57				724	865
ENE	42				600	766
E	47	81	88	8	624	782
ESE	42				562	717
SE	57				638	762
SSE	50				649	799
S	47	81	88	8	685	859
SSW	84				128	119
SW	56				15	0
WSW	42				12	0.9
W	47	81	88	8	15	1.5
WNW	42				10	0.6
NW	34				14	1.1
NNW	84				21	3.5

[a] B, C, and D stabilities were only partially modeled since concentrations appeared to be independent of wind direction.

TABLE 2-9. UPDATED MAXIMUM 24-HOUR TSP CONCENTRATIONS CAUSED BY EMISSIONS FROM THE TAILINGS POND, ($\mu g/m^3$ except as noted)

Stability class Wind speed, m/s	A 2.5	B[a] 4.47	C[a] 5	D[a] 13.41	E 2.5	F 2.5
Radial direction from smelter						
	0	0.2	0.4	17		
N					0	0
NNE					0	0
NE			1.0		0	0
ENE		0.4	1.0		0	0
E		0.4	1.0	31	0	0
ESE		0.4		22	0	0
SE					0	0
SSE			0.1		0	0
S		0.2	0.4	18	0	0
SSW		0.3	0.7	28	0	0
SW		0.4	1.1	30	0	0
WSW		0.7	1.5	24	0	0
W		0.9	2.1	41	0	0
WNW		0.9	1.9		0	0
NW		0.5	1.2	31	0	0
NNW		0.3	0.8	28	0	0

[a] Only selected modeling was performed with results indicating no potential violations. Receptors not modeled are expected to be equal to or less than indicated value.

TABLE 2-10. UPDATED MAXIMUM 24-HOUR TSP CONCENTRATIONS CAUSED BY EMISSIONS FROM THE MAIN STACK, SMELTER FUGITIVES, AND TAILINGS POND, ($\mu g/m^3$ except as noted)

Stability class Wind speed, m/s	A 2.5	B[b] 4.47	C[b] 5	D[d] 13.41	E 2.5	F 2.5
Radial direction from smelter						
N	199	106	113	51	58	44
NNE	183				194	296
NE	158				749	890
ENE	213				625	915
E	199	107	114	64	1279	1849
ESE	213				663	1038
SE	158				975	1914
SSE	183				688	1040
S	199	106	113	51	710	884
SSW	167			57	153	145
SW	219			55	40	25
WSW	213				37	26
W	199	107	114	75	40	27
WNW	213				35	26
NW	219			56	39	26
NNW	167			56	46	29

[a] Includes background concentration of 25 $\mu g/m^3$.

[b] B, C, and D stabilities were only partially modeled since concentrations are only slightly dependent on wind direction and no violations are expected.

secondary standard violations are estimated under A stability for total concentrations. Violations detected on nearby terrain are noted for stabilities E and F. Table 2-7 shows that emissions from the main stack contribute to estimated violations under E and F stability, at receptors on the terrain to the east of the plant. The main stack emissions also contribute to the estimated exceedances of the secondary NAAQS (150 $\mu g/m^3$) under A stability at receptors in the valley. Fugitive emissions from the smelter also contribute to violations of the secondary NAAQS at the same receptors as the main stack under A stability, but at different receptors under E and F stability conditions (downwind distances not shown). Emissions from the tailings pond are not estimated to cause any violations of the 24-hour standard under the assumed conditions. No monitors are located at sites estimated to receive maximum concentrations of emissions primarily from the main stack. This indicates that monitors should be located in the vicinity of these maximum impact areas to detect maximum concentrations. The McGill School Monitor (State Site 29-0560-002), however, lies about 1.6 km to the south-southeast of the main stack (0.8 km from potential fugitive emissions) and is positioned such that maximum 24-hour concentrations due to the combined smelter fugitive and the main stack emissions may be monitored. Upon examination of the STAR data gathered at the Ely Airport weather station from 1973 to 1976, it was found that conditions conducive to a maximum impact at the McGill monitor as a result of emissions from the main stack (A stability, north to

windspeed) occurred only over one 3-hour period in 4 years. Similarly, conditions that may lead to a maximum impact at the McGill site as a result of fugitive emissions from sources at the plant (F stability, north to east-northeast winds, and 1- to 3-m/s windspeeds) occurred for thirty-two 3-hour periods (0.74 percent of total). Thus, the Valley Model indicates that the fugitive emissions from the smelter contribute most frequently to potential violations of the 24-hour TSP standard at the McGill school monitor.

A basic consideration in applying the Valley Model is whether the worst-case assumptions are reasonable, i.e., does the model consider a worst-case concentration estimate based on a reasonable combination of representative meteorology, source characterization, plume rise, and plume dispersion? This consideration is especially important when one estimates the maximum impact and location of such impact in regard to emissions from the main stack. All other sources modeled thus far are based on receptors in flat terrain because there is little evidence to treat area source dispersion in complex terrain any differently. On the other hand, point sources under stable, light-wind, limited mixing conditions tend to emit plumes that often level off after achieving final plume height and flow toward, around, or over downwind elevated terrain in ribbons or sheets.[8] Thus, the Valley Model is applied to the main stack at McGill with this type of worst-case scenario in mind. The wind rose for Ely, Nevada, in Figure 2-1 shows that winds from the southwest through

Figure 2-1. Windrose for Ely, Nevada, 1973-1976; all stabilities.

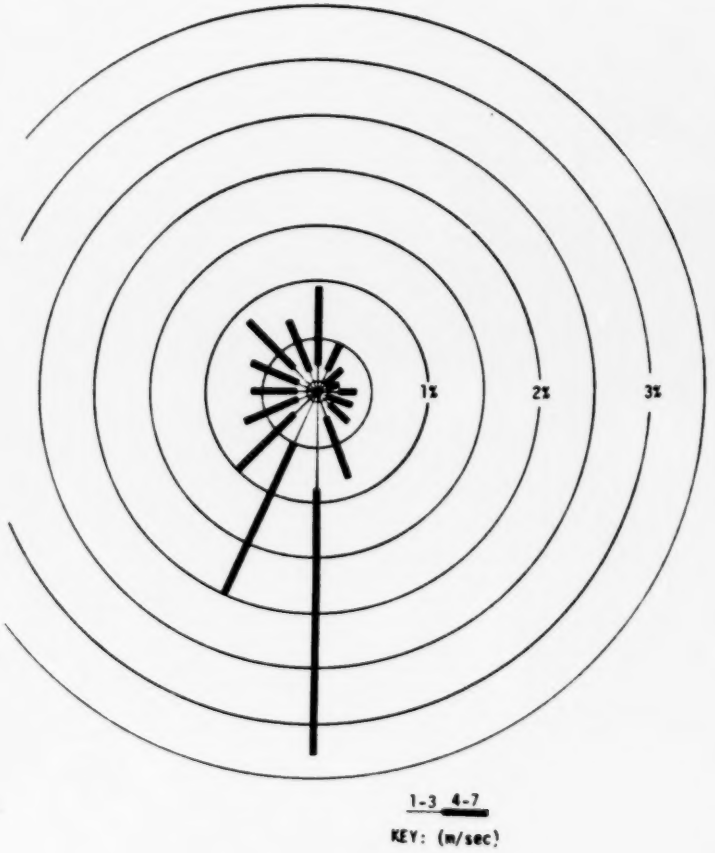

Figure 2-2. Windrose for Ely, Nevada, 1973-1976; F-stability.

north occur about 37.2 percent in a given year. Since the National Weather Service readings are only taken every 3 hours and are not 3-hour averages but rather 1-minute averages, the wind rose derived from the airport is not necessarily suited for modeling. These roses, however, are indicative of the atmospheric conditions near the plants and provide at least a continuous, though limited, record. Further examination of the Ely, Nevada, annual wind rose indicates that for the directions just discussed (SW, WSW, W, WNW, NW, NNW, N), windspeeds of 1 to 3 m/s occur about 3.5 percent of the time. The worst-case estimates for the main stack, however, occur under light windspeed, F stability conditions. Figure 2-2 shows a similar wind rose, but only for F stability conditions. When only considering winds from the W, WNW, NW, and NNW wind directions toward the terrain at windspeeds of 1 to 3 m/s during F-stability conditions occur about 1.0 percent of the time. Thus, the surface-based observations demonstrate the possibility of the occurrence of conditions conducive to plume dispersion toward the eastern mountains.

The main stack is 229 m tall. The windspeeds and directions at the surface may be very different from those at plume height (under F stability, 2.5 m/s, the final plume height approximated by the Valley Model is about 345 m above the stack base). Thus, the extrapolation of surface data to plume height is at best an estimate of the atmospheric conditions affecting dispersion from the main stack. A better indicator is found by examining upper air summaries taken from twice-a-day soundings at the Ely airport.

The early morning soundings (0400 local standard time [l.s.t.]) are best suited to characterizing the winds at stack height. Table 2-11, which summarizes these conditions, is derived from Inversions Study, Percentage Frequency of Temperature, Relative Humidity, and Wind (Seasonal and Annual).[16] Because only the four cardinal directions are given in the report, the winds from the west are chosen as the most representative of conditions conducive to plume impaction. Again, these are only indicators of how often these conditions may occur.

In summary, the results EPA and Kennecott obtained by using the Valley Model are verified in an updated and independent modeling analysis performed by PEDCo. The analysis indicates that the main stack has a significant impact on terrain to the east of the smelter under meteorological conditions that occur about 1.3 percent of the time (about 114 hours) at the plume height. Since this percentage is expressed as a portion of the total number of hours in a frequency distribution, no specific information on the number of sequential hours (persistence) with these conditions is given. Very limited monitoring data, however, exist to conclusively support the occurrence of high concentrations on the terrain. Under the assumed conditions in the analysis, the Valley Model indicates that emissions from the tailings pond have very little impact. The results also demonstrate, however, the potential high impact of the fugitive emissions from the smelter on receptors within 2 km of the smelter. This conclusion is supported by monitored excursions of the 24-hour TSP NAAQS at

TABLE 2-11. SUMMARY OF WINDSPEED AND INVERSION DATA NEAR PLUME HEIGHT (~350 METERS) OF THE McGILL SMELTER MAIN STACK FROM ELY AIRPORT MORNING SOUNDINGS (1960-1964)

Inversion conditions		Wind-speed, m/s	Wind direction (0)	Season	% frequency of Occurrence[a]
Base height, m	Thickness, m				
Any inversion		2.5-5.0	W	Yearly	4.5
Surface to 100	251-500	2.5-5.0	W	Yearly	1.3
Surface to 100	251-500	2.5-5.0	W	Winter	2.8
Surface to 100	251-500	2.5-5.0	W	Spring	0.9
Surface to 100	251-500	2.5-5.0	W	Summer	0.7
Surface to 100	251-500	2.5-5.0	W	Fall	0.9

[a] Frequencies are not additive since they are expressed as percentages of the observations with the given conditions, i.e., 2.8% of all winter time upper air observations had conditions that may lead to plume dispersion towards the mountains.

monitors near the smelter and by the frequent occurrence of meteorological conditions conducive to such impacts. This result is also supported by EPA's statistical analysis showing more violations when the smelter is operational than when it is down (see Section 7). More fugitive emissions from the smelter are generated when the plant is operational.

2.3 REQUIRED EMISSION REDUCTIONS

In order to meet the ambient air quality standards for TSP, concentrations at the monitors and/or receptors must be in compliance. In this case, the most restrictive concentrations would appear to be the 24-hour values. The highest 24-hour concentration estimated by Valley under worst-case conditions is 1914 $\mu g/m^3$, which occurs at 1.5 km to the southeast of the plant at an elevation of 7600 feet above sea level. Based on the maximum contribution possible from each source (i.e., main stack - 1789 $\mu g/m^3$, fugitive emissions - 100 $\mu g/m^3$, tailings pond - 0 $\mu g/m^3$, and background - 25 $\mu g/m^3$), the control of emissions from the main stack seems most appropriate. Subtracting the fugitive and background contributions from the TSP primary NAAQS (260 $\mu g/m^3$) results in a required reduction to 135 $\mu g/m^3$ at the main stack. Similarly, for the secondary NAAQS (150 $\mu g/m^3$), the main stack is required to reduce to a maximum impact of 25 $\mu g/m^3$. The following proration of emissions indicates the required emission control levels.

$$\text{Primary NAAQS} = \frac{1789 - 135}{1789} = 92 \text{ percent control}$$

$$\text{Secondary NAAQS} = \frac{1789 - 25}{1789} = 99 \text{ percent control}$$

Therefore, based on data obtained by using the Valley Model, control of 92 percent of the emissions from the main stack should enable the McGill Smelter to meet the primary TSP NAAQS, as estimated at receptors located in the eastern mountains. Because of extremely different source dispersion and the interaction of pollutant flow in the complex terrain near the smelter, the control of the main stack may not be sufficient to avoid violations of the NAAQS at all locations around the plant site. This fact is especially evident when consideration is given to the impacts the fugitive emissions from the smelter may have on nearby receptors (see Table 2-8). Thus, this analysis indicates a combined control strategy for the important sources may be necessary to insure compliance at all receptors. Since the emission estimates for the fugitives at the smelter are tenuous and no source specific emissions are developed, including them in a source control strategy is difficult at this point.

2.4 SUMMARY

PEDCo has verified all inputs and results as originally modeled by EPA and Kennecott. Based on updated and/or revised source characteristics, meteorological data, and receptor locations, similar results are obtained for both the 24-hour and annual average calculations. After a review of several evaluations of the Valley Model in the literature, the conclusion is

drawn that it estimates maximum concentrations generally within a factor of two. Under some conditions Valley may overestimate by more than a factor of two. Only one case identified a source/receptor distance similar to that at McGill with concentration estimates four times the observed. The method of application employed by EPA and Kennecott appears to be consistent with the Guideline on Air Quality Models[6] and the Regional Workshops on Air Quality Modeling,[7] although documentation provided to PEDCo is incomplete.

The following list describes the most serious inadequacies in the modeling besides the model itself:

- Undetailed treatment of tailings pond emissions
- Undocumented background concentration
- Inadequate discussion of source contributions

The first two points will be addressed in a subsequent chapter and analysis in this report. The last point is very important. If a control strategy for the main stack is applied and the stack is an isolated point source, then emission reductions would certainly protect the air quality in the Steptoe Valley. The main stack is not isolated, however, and it is surrounded by other sources of particulate emissions that have been demonstrated through modeling also to contribute to violations of the standards. Monitoring data and visual observations taken by Kennecott have also demonstrated that under higher windspeed conditions emissions from the tailings pond may exceed the standards (even when the smelter is down). Thus, control of the tailings pond,

the smelter fugitives, and the main stack emissions appear to be required to ensure protection of the NAAQS under all meteorological conditions at all sites in the Steptoe Valley.

REFERENCES FOR SECTION 2

1. Kennecott Copper Corporation. An Analysis of Kennecott's Particulate Control Strategy at the McGill Nevada Operations. Submitted to U.S. Environmental Protection Agency. July 30, 1979.

2. Kennecott Copper Corporation. An Emission Inventory and Assessment of the Particulate Control Strategy for the McGill Operations of the Kennecott Copper Corporation. Submitted to U.S. Environmental Protection Agency. August 7, 1979.

3. TRW Systems Group. Air Quality Display Model. Prepared for National Air Pollution Control Administration, DHEW, U.S. Public Health Service. Washington, D.C. November 1969.

4. Halitsky, J., et al. Validation Studies of a Modified Potential Flow Model for Dispersion in Complex Terrain Submittal and Summary of Comments of Kennecott Copper Corporation. Unpublished. September 21, 1979.

5. Burt, E. W. Valley Model User's Guide. EPA-450/2-77-018. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina 27711. September 1977.

6. U.S. Environmental Protection Agency. Guideline on Air Quality Models. EPA-450/2-78-027. Research Triangle Park, North Carolina 27711. April 1978.

7. U.S. Environmental Protection Agency. Regional Workshops on Air Quality Modeling: A Summary Report. Office of Air Quality Planning and Standards. Durham, North Carolina. September 1979.

8. Burt, E. W., and H. H. Slater. Evaluation of the Valley Model. Presented at the AMS-APCA Joint Conference on Applications of Air Pollution Meteorology. Salt Lake City, Utah. November 29 to December 2, 1977.

9. Churton, B. M., et al. Modeling vs. Monitoring: A Refining Case History in Complex Terrain. Preprint No. 23-80. Presented at the 45th Michigan Refining Meeting. Houston, Texas. May 14, 1980.

10. Holman, H. Y., and S. R. Hayes. Survey and Assessment of the Literature on the Performance Evaluation of Selected Gaussian Models. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. February 1979.

11. Luntz, R. B., G. F. Hoffnagle, and S. B. Pawha. Diffusion Model Comparisons to Measured Data in Complex Terrain. Third Symposium on Atmospheric Turbulence, Diffusion, and Air Quality. American Meteorological Society. Raleigh, North Carolina. October 1976.

12. Slowick, A. A., and N. Pica. A Field Comparison of the EPA "Valley" Model, "Half-Height" Model, and a Suggested New Model in Complex Terrain Under Stable Atmospheric Conditions. Pennsylvania Electric Company, Johnstown, Pennsylvania. August 31, 1976.

13. Turner, D. B., and A. D. Busse. Users' Guides to the Interactive Versions of Three Point Source Dispersion Programs: PTMAX, PTDIS, and PTMTP. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. June 1973.

14. U.S. Environmental Protection Agency. Air Quality Data - 1977 Annual Statistics. EPA-450/2-78-040. Research Triangle Park, North Carolina. September 1978.

15. Larsen, R. I. A Mathematical Model For Relating Air Quality Measurements to Air Quality Standards. AP-89. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. November 1971.

16. National Climatic Center. Inversion Study 1960-1964. Job No. 13105. Asheville, North Carolina. June 18, 1973.

SECTION 3

ANALYSIS OF KENNECOTT'S DECEMBER 13, 1979, SUBMITTAL

On December 13, 1979, Kennecott submitted a report outlining their position on whether the McGill Smelter contributes to violations of the TSP NAAQS. The report, entitled "Kennecott Minerals Corporation Notice of Violation Conference," consists of four parts:

1. Overview of the issues
2. Summary of a monitoring research program
3. Airborne plume measurement program
4. Overview of 1972 SO_2 measurement program

The primary focus of Kennecott's paper is that violations of the TSP NAAQS are caused by the tailings pond and not the main stack. Their methodology is to demonstrate that emissions from the main stack do not contribute significantly to air quality readings taken at receptor locations in the Steptoe Valley and in the mountains to the east of the plant. Concentrations of SO_2 and TSP are compared at several monitor locations, based on the assumption that ratios of SO_2/TSP emissions from the main stack are constant. Since the main stack is the primary source of SO_2 emissions in McGill, Kennecott assumed that SO_2 emissions and downwind concentrations would be a reasonable surrogate for

tracking the TSP contribution of the main stack. Thus, Kennecott describes the SO_2 concentrations at several monitors, applies an SO_2/TSP emission ratio factor (average factor of 29.1 or 30 from Method 5 tests), and estimates the TSP contribution of the main stack. The difference in total TSP and estimated TSP from the main stack is attributed to other sources in the area (fugitive emissions from the smelter, emissions from the tailings pond, crushing operations, etc.).

Limited special monitoring and SO_2 monitoring conducted in 1972 are used to substantiate Kennecott's position. They also present a report by North American Weather Consultants[1] that examines the SO_2/TSP ratio at distances downwind from the main stack where maximum concentrations are expected to occur. The following sections discuss various portions of Kennecott's submittal.

3.1 KENNECOTT'S NOVEMBER 1979 RESEARCH PROGRAM

Kennecott conducted a research program aimed at determining the effect of smelter emissions on ambient particulate concentrations in the area surrounding the smelter. Concentration of TSP can be determined by tracking the dispersion of and downwind concentration of SO_2, provided the main stack is the only source of SO_2 in the McGill area and that the TSP behaves as a gas (the particulates are less than about 20 μm in size). This methodology is strongly dependent upon the final assumption that the ratio of SO_2/TSP emissions in the stack gases is known, remains

constant over time, and will remain consistent after plume dispersion. Kennecott took 39 measurements of SO_2/TSP ratios using Method 5 procedures; the average ratio of all cases is about 30. This SO_2/TSP ratio is used together with measured SO_2 data to estimate the maximum impact of TSP emissions from the main stack. Kennecott demonstrates that the worst-case impact of the smelter stack is about 9 $\mu g/m^3$ for valley monitors, 30 to 108 $\mu g/m^3$ for a mountainside monitor (based on 1972 SO_2 data), and about 6 $\mu g/m^3$ (based on a 1979 mountainside measurement).

The basic inadequacies in this analysis stem from Kennecott's use of a ratio of 30, the very limited data base and monitoring program, and the limited modeling performed to establish other source contributions to the NAAQS violations. As stated in Kennecott's submittal, several other particulate sources, including emissions from the tailings pond, smelter fugitive emissions, etc., may contribute to the TSP concentrations. Though determined by EPA to be inappropriate, Kennecott's previous analysis of these sources should have provided an overview of source contributions and interactions under various meteorological conditions. Kennecott did not discuss this adequately.

The monitoring program included in the report (PEDCo did not receive Tables 1 and 2 of this submittal) appeared to be very limited, especially in regard to the mountainous regions. Only a 2-week monitoring program (November 12 to December 1, 1979) conducted at two sites (one corresponded to the maximum impact location designated by EPA) is presented. This program is inadequate for a discussion of a 24-hour maximum or secondary maximum

because of the slim chance that worst-case meteorological and emission conditions would occur at the same time. Also, the 1972 SO_2 data presented in the submittal include only one data point, situated about 1.3 km (0.8 mile) to the east of the main stack. The measured value of SO_2 at this location is 6280 $\mu g/m^3$ for a 30-minute average or, based on Kennecott's conversions, about 904 to 3252 $\mu g/m^3$, depending on the 24-hour extrapolation factor used. Additional monitoring may yield substantially higher concentrations of SO_2.

Kennecott's use of an SO_2/TSP ratio of 30 is inconsistent with establishment of a potential worst-case emission scenario. If TSP emissions are assumed to be 2100 lb/h as a worst case, as in Kennecott's previous short-term modeling, then a more representative SO_2/TSP ratio is one near this level of TSP emissions. Several cases in Kennecott's submittal illustrate this point, with SO_2/TSP ratios ranging from 13.1 to 16.7, or about half of the assumed value of 30. Use of these values may substantially increase the TSP estimate in Kennecott's analysis, especially for the upper limit of the mountainside analysis, e.g.:

$$3252/13.1 = 248\ \mu g/m^3$$

$$3252/16.7 = 195\ \mu g/m^3$$

Thus, the limited data base presented by Kennecott indicates that the main stack may exceed the secondary TSP NAAQS on nearby terrain. In addition, the data in Kennecott's submittal show a wide variation in the SO_2/TSP ratio and consequently, the use of a constant ratio is probably not justified. The data are so

limited, however, that no reasonable or defensible conclusion can be made.

3.2 REVIEW OF NORTH AMERICAN WEATHER CONSULTANTS STUDY

In September 1979, North American Weather Consultants performed an air sampling program of the plume emitted from the main stack of the McGill Copper Smelter. Kennecott's primary purpose for this study was to track the SO_2/TSP plume under stable, light-wind conditions and to determine if an SO_2/TSP ratio of 30 is maintained out to distances of potential plume impaction. Winds to the north of the stack are required to enable an aircraft to penetrate the plume and to provide a relatively undisturbed (by complex terrain) plume.

According to North American Weather Consultants, the purpose of the air sampling program was "to examine particulate dispersion rates along the plume centerline and compare the data with estimates provided by centerline concentration and horizontal dispersion components of Gaussian dispersion models."[3]

The sampling rationale is as follows:

1. Under stable meteorological conditions, SO_2, TSP, and SF_6 were sampled in the Kennecott plume 2 km downwind from the plant. The SF_6 gas was released and the emission rate (source strength) was measured. The dispersion rate based on the concentration-emission ratio, $\chi SF_6/Q_{SF_6}$, was applied to the measured TSP and SO_2 concentrations in order to estimate TSP and SO_2 source strengths emitted from the stack.

2. The distance of 2 km was selected because it is the approximate distance to the nearest high terrain, where highest ground-level concentrations were expected via modeling.

3. A model was applied to the meteorological and source strength data to calculate peak plume centerline concentrations at 2 km from the stack.

4. A series of traverses was made through the plume at the estimated height of maximum concentration. The edges of the plume were determined by the response of a nephelometer that is sufficiently sensitive to locate a coherent plume within 1 to 2 seconds of encountering it if the aircraft is flying at nominal sampling speeds. This device is not very accurate for use in estimating the time in the plume, which in turn is used to estimate the appropriate total volume flow through the particulate sensor, especially considering the narrow plume width (100 to 200 m) at 2 km downwind.

It should be noted that the report is ambiguous on several points. Contradictory dates for the sampling activity are given. The report provides no information as to the number, times, duration of the traverses or measured data on any traverses, plume dimensions, vertical temperature profiles, nature of wind calculations, aircraft speed, or sample flow rates. The TSP and SO_2 source strengths are determined in a generally ambiguous manner. It is therefore not possible to replicate the data presented in the tables of the report. All conclusions must be based on the data presented in the tables.

The investigators strive to ascertain a peak concentration. The averaging time or spatial dimensions of the peak are not specified. Why this approach was taken is not known, since the shortest NAAQS for TSP is 24 hours. The objective should have been to obtain a validation of a dispersion coefficient for a longer period, perhaps for an hour.

Given their approach, there is a requirement to sample through the plume centerline. Because this is very difficult to do on each traverse, the maximum number of traverses possible should be made. The report only estimates the approximate number of traverses that are made and does not indicate the number needed to locate the centerline altitude.

The authors attribute the variability of the peak concentrations on each traverse to the sampling technique and source strength variations. Another equally likely cause is the inherent variability of the contaminant's distribution within the plume that results from the turbulence of the atmosphere. It is remarkable that these fluctuations are not much greater. This is the reason that dispersion coefficients are expected to represent some statistic of random nature of turbulence and the reason Gaussian approaches are used to such an extent in estimating impacts.

The reason for citing the Valley Model is unclear. This model is not used and is not applicable to an averaging time appropriate to a plume traverse. The mean data developed in this study tend to support some of the input data often used in the Valley Model.

Apparently serious difficulties arose in obtaining proper flow rates for the TSP measurements on September 16. Therefore, TSP data for the first four data series are suspect. Valid data are provided only by Series 5 and 6 on September 17, which provided a total of 2-1/2 hours of "flight time" and an unspecified period of plume sampling time. This is an inadequate sample

on which to base judgments as to typical dispersion characteristics of the area. Nevertheless, Ely is located in a geographical area that experiences circumstances similar to those that prevailed on September 17 (see Holzworth,[2] EPA 650/4-74-002, 1974 and Holzworth and Fisher,[3] EPA 650/4-79-026, 1979).

The early morning NWS upper-air soundings obtained from Ely Airport show F stability near the surface on all days (Figure 3-1). The top of the inversion on September 16 is 254 m, however, and the smelter plume may have penetrated it. Unless the flight operations were begun by sunrise or very shortly thereafter, the plume would have been changing its character very rapidly. Under these circumstances, it is remarkable that the model/measured ratio for SF_6 was between 1.0 and 1.2. The dispersion coefficients must apply well to the Kennecott area, and the investigators made excellent meteorological decisions.

Kennecott's argument that the SO_2/TSP emission ratio "is about 30" is not supported by the results of this flight and data analysis study. The data that apply are the measured mean peak SO_2 and TSP concentrations on Data Series 5 and 6, where the SO_2/TSP ratios are $\frac{40410}{4355} = 9.3$ and $\frac{53968}{2791} = 19.3$. Thus, Kennecott appears to overestimate the ratio of SO_2/TSP when using a ratio of 30. In addition, the data indicates that the ratio is not a constant.

3.3 REVIEW OF 1972 SO_2 BUBBLER DATA

As part of their December 13, 1979, submittal, Kennecott included measurements of SO_2 taken around the smelter in 1972.

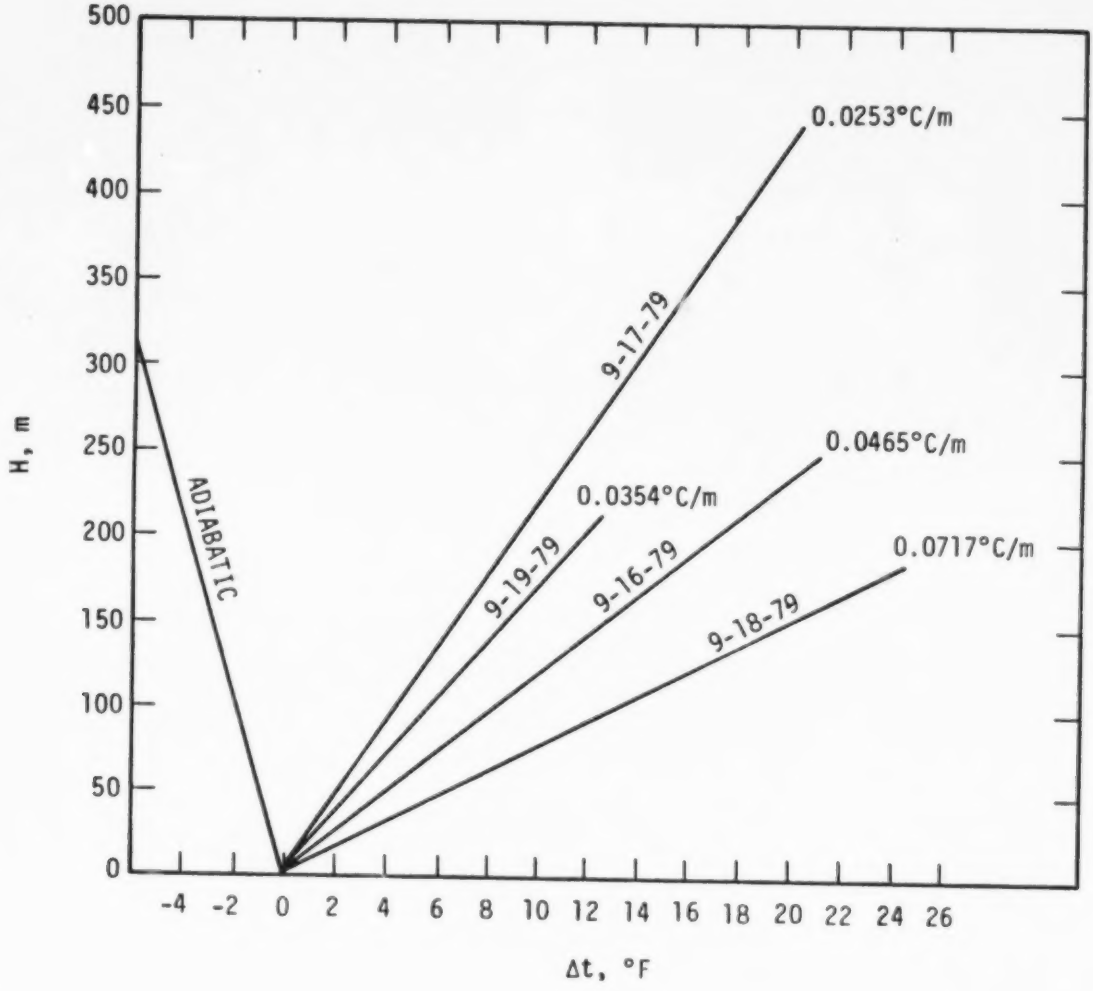

Figure 3-1. NWS temperature versus height for Ely, Nevada, September 16-19, 1979.

Concentrations are presented for the following dates: August 24-27, 1972, and September 3-13 and 26-28, 1972. These concentrations were measured at various sites near the tailings pond, north of the plant at Gallagher Gap, northeast of the plant in the foothills, and due east of the plant near the point that the Valley Model estimated to have the maximum plume impact. The 30-minute concentration (6280 $\mu g/m^3$) presented for August 24, 1972, at 0.8 mile or 1.3 km east of the plant is the highest concentration in the data presented by Kennecott. No other data are presented for this particular site and no details are given concerning windspeeds, wind direction, or general atmospheric and emissions conditions.

All SO_2 samples are collected by using a RAC bubbler, Model 440-B, over a 30-minute period at a rate of 1 liter of air sampled per minute. The laboratory method of analysis utilized the Pararosaniline Method that was published in the 1972 Federal Register and in the Code of Federal Regulations, Part 40, Chapter 1, 1972. As specified in the suggested methodology, the samples were kept in insulated boxes with ice to deter further sample reaction. No refrigeration other than the insulated boxes was available because of the remote site location of the monitors. During sampling, the bubblers were shielded from the sun to maintain lower sampling temperatures and prevent sample reaction. The barometric pressure was noted and adjusted for the site elevation. Thus, all airflows were corrected for the proper conditions.

Based on discussions with Kennecott personnel who actually carried out the 1972 SO_2 measurement program, the results presented appear to be reasonable and within the limits of the 1972 quality control methods.

3.4 SUMMARY

The 4-day aircraft study provided 2-1/2 hours of flight time, during which the investigators concluded that valid and useful data for all aspects of the study were collected. Actually, these data were collected on one day, September 17, 1979. This is an inadequate sample to judge the character of the dispersion of the area.

No dispersion "components" are presented, as the stated purpose of the study would imply. Based on the most reliable data (SF_6), however, the mean concentration ratios for the model were 1.00 to 1.28. These are the most representative data for the stated purpose of the study since the NAAQS for TSP is a 24-hour average and not a peak value. These data confirm that the centerline model worked remarkably well. Though the sample is small, the result supports the applicability of a Gaussian model.

An unresolved problem in this experiment is the SO_2/TSP emission ratio. Kennecott's estimate of the SO_2/TSP ratio exceeds those experimentally derived in the plume by a factor of 1.5 to 3.2. The experiments also show that the SO_2/TSP ratio varies widely and is not a constant as assumed by Kennecott. Thus, the results presented in Kennecott's portion of this document do not consider the experimentally derived plume SO_2/TSP ratio and do

not reflect the potentially higher concentrations found if a lower value of the ratio is used. Higher concentrations are especially noted if the SO_2 concentration measured over a 30-minute averaging period in the mountains to the east of the plant is extrapolated to a 24-hour average and converted to a TSP concentration.

REFERENCES FOR SECTION 3

1. Schanot, A. J., et al. Aerial Measurements of Plume Dispersion at the McGill Smelter. NAWC-SLC-79-13. North American Weather Consultants. Salt Lake City, Utah. November 1979.

2. Holzworth, G. C. Meteorological Episodes of Slowest Dilution in Contiguous United States. EPA-650/4-74-002. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. February 1974.

3. Holzworth, G.C., and R. W. Fisher. Climatological Summaries of the Lower Few Kilometers of Ravinsonde Observations. EPA-600/4-79-026. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. May 1979.

SECTION 4

REVIEW OF KENNECOTT'S SEPTEMBER 21, 1979, SUBMITTAL COMMENTING ON EPA'S 110g ACTION

Table 1-1 in Section 1 contains a chronological listing of SIP strategies to control TSP at the McGill Copper Smelter. Kennecott submitted two TSP control strategies to EPA on July 30 and August 7, 1979, parts of which have been reviewed in previous sections of this report. The EPA has not yet approved control strategies for Kennecott's smelter and/or the revised October 7, 1976, SIP TSP emission regulations. In the interim, the Governor of Nevada issued a 110(g)(1) suspension of Article 7.2 to allow Kennecott to continue operations. On September 13, 1979, however, EPA disallowed the suspension because Kennecott failed to demonstrate that the SIP revision upon which the suspension was issued would protect the NAAQS. Kennecott submitted a reply on September 21, 1979, in response to EPA's "Disapproval of Temporary Emergency Suspension of an Implementation Plan," 44 Federal Register 53305 et seq., September 13, 1979. This submittal consists of three parts:

- Comments prepared for EPA and submitted by Kennecott's legal counsel, Mr. Alfred V. J. Prather.
- Answers to EPA's objections provided by a September 11, 1979, hearing record.
- Kennecott's comments and technical papers submitted as part of the September 11, 1979, hearing record.

4.1 COMMENTS OF KENNECOTT COPPER CORPORATION

The first part of Kennecott's September 21, 1979, submittal is essentially a four-page summary describing the state of affairs. Kennecott was confused and dismayed at EPA's failure to attend a public meeting on September 11, 1979. During this time, Kennecott and the State of Nevada anticipated that they had not resolved EPA's objections to the SIP revision. Despite this fact, the SIP revisions adopted by the State at the hearing were submitted to EPA and a new suspension order was issued. The submittal states the basic issues between EPA and Kennecott: (1) Do smelter emissions cause violations of the 24-hour NAAQS, and (2) Can present emission limitations be met by reasonably available control technology? Kennecott's legal council suggests these matters be resolved before any type of litigation proceeds and also appeals to EPA for further meetings to aid in their resolution.

4.2 REPLIES TO EPA'S OBJECTIONS

The Nevada State Environmental Commission held a public hearing in Reno, Nevada. Afterward, on September 11, 1979, the Commission adopted amendments to the TSP emission regulations. These amendments were intended to eliminate EPA's objections to the Nevada State Implementation Plan and the Governor's August 24, 1979, suspension order. Of the five objections mentioned in Kennecott's replies, the most critical is the first:

> First, the revision does not provide for attainment of the ambient standards, as required by Section 110(a)(2)(A) [of the Clean Air Act]. The control strategy submitted by the State shows that the revision is inadequate to protect the ambient standards. Contrary to Kennecott's statements, emissions from the smelter stack contribute significantly to violations of the ambient standards for particulate matter. Indeed, under certain circumstances, the stack emissions alone can cause violations of the ambient standards.

After reviewing all pertinent information in Kennecott's submittals, and in light of the state-of-the-art of dispersion modeling and the decisionmaking process for regulating emissions, agreement on the main stack impact seems to be a critical point. In terms of available modeling and guidance a screening analysis has shown potential high concentrations, but a more refined analysis and/or monitoring program would help fortify or disprove the main stack impact. Kennecott has attempted to improve modeling efforts using the Hydrodynamic Model, but it is not recognized by EPA as valid. Only limited TSP monitoring has been made on the Duck Creek Range to the east of the smelter. No TSP elemental samples have been analyzed in an attempt to identify a source.

Much can be learned about source impacts through visual inspection of the tailings pond and the main stack. Under light wind and stable conditions, a stack can have an impact on the mountains to the east (see August 24, 1972, SO_2 bubbler data). At one monitor site operated by the State and three operated by Kennecott, the main contributors generally appear to be emissions from the tailings pond and fugitive emissions from the smelter. Kennecott personnel noted that emissions from the tailings pond

filled the valley on occasion and that the highest emissions from the smelter fugitives occurred during its operation. The impact of tailings pond emissions is not expected to be very great on the mountainsides because of the small amount of reentrainment of tailings particles that occurs at heights as high as the main stack and the low frequency of windspeeds toward the mountains that are sufficient to induce particle entrainment. Windspeeds greater than 10 mph suspend tailings particles, however, and these are often noted blowing up and down the valley. Thus, conditions in which emissions from the main stack are most likely to have a maximum impact on surrounding terrain are dissimilar to conditions in which tailings are most likely to have their maximum impact. Only in a slightly unstable to neutral atmosphere and under sufficient wind conditions are the two major TSP emission sources (tailings pond and main stack) expected to combine impacts of potentially equal magnitude.

4.3 REVIEW OF KENNECOTT'S TECHNICAL PAPERS

Several additional comments and technical papers were submitted by Kennecott to the Nevada State Environmental Commission on September 11, 1979, in support of their position. Four parts of these comments are statements on behalf of Kennecott that seek primarily to disprove EPA positions and conclusions. In summary, the control techniques proposed are found by Kennecott to be economically and technically infeasible, the emission regulations are not needed to protect the NAAQS, the tailings pond will be controlled, and the NAAQS will be achieved under the Nevada SIP.

Dr. Frederick Templeton's statement concerning these proceedings is probably the most succinct summary of Kennecott's position and their attempts to meet EPA requirements. The rest of this document gives an overview of various attempts to modify and use the Valley Model, discussions of the Hydrodynamic Model applications, and previous control strategy submittals (including emission inventories and modeling). Dr. Templeton states that Kennecott has attempted to demonstrate the smelter's impact on the area around McGill. The use of the Hydrodynamic Model, however, has not been approved by EPA, and the Valley modifications suggested in the Kennecott report are not documented, nor have they been approved by EPA for use in regulatory analysis. Thus, over the past 8 to 10 years, various dispersion models have been applied to the McGill smelter to estimate concentrations on the terrain to the east of the plant. Unfortunately, the state-of-the-art modeling techniques available for this analysis have not improved significantly, nor have any new techniques been recommended by EPA for general use.

SECTION 5

DEVELOPMENT OF A REFINED TSP INVENTORY AND RELATED DISPERSION MODELING ANALYSIS

5.1 INTRODUCTION

None of the data bases used as input to dispersion modeling performed by either KMC or EPA included an adequate inventory of the TSP emission sources surrounding the McGill Smelter. In one of the KMC submittals, an inventory of particulate emissions for White Pine County was presented along with a somewhat more detailed estimate of emissions for various areas of the tailings pond. No modeling was performed with this inventory. All sources in the vicinity of the smelter should be included in the data base to ensure a more adequate investigation.

PEDCo was directed to prepare a comprehensive inventory of all sources of particulate emissions within the immediate vicinity of the smelter. A microinventory was conducted of the area within 8.0 km of the plant. The microinventory provides information on fugitive emissions from process operations, the tailings pond, and other area sources and on particulate emissions from the main stack at the smelter and the stack of a small boiler at the smelter.

The microinventory does not include emissions from the boiler at the McGill Elementary School. Available information

indicates that particulate emissions from the school boiler are negligible and therefore have little or no impact upon air quality. Further, the KMC and EPA reports do not discuss this boiler.

New modeling is limited to a 24-hour and annual average application of the Valley Model. The Valley Model was selected for consistency with previous EPA-approved modeling and with current EPA guidance.

Based on previous modeling and on the relationship of fugitive emissions to windspeed, the meteorological conditions causing worst-case, 24-hour, TSP concentrations were determined. The conditions for worst-case particulate emissions from the main stack and worst-case fugitive emissions from process operations, the tailings pond, and other area sources are as follows:

Main stack	-	F stability (very stable) Wind speed of 2.5 m/s Impact on mountains to the east (1.5 km)
Process operations	-	D stability Light winds (<3 m/s) Main impact near smelter (<1 km)
Tailings pond and other area sources	-	D stability High winds (6-10 m/s) Main impact near sources (<1 km)

This updated inventory will have little impact on the contributions of the fugitive particulate sources to the impact on the mountains to the east of the plant. Thus, the conditions leading to the maximum mountainside concentration are still due to only the main stack and need not be remodeled. The focus will rather

be to model the conditions leading to potential worst-case combined impacts of the fugitive sources and the main stack.

5.2 EMISSION INVENTORY

The particulate emission inventory consists of two parts. One concerns the tailings pond, including active areas and areas under some measure of control. The other concerns remaining areawide, nonpoint sources (i.e., minor stationary combustion sources, mobile sources, open-burning sources, and fugitive dust sources), which are grouped into an areawide grid system. The only major point sources identified in this study are the main stack and the coal-fired boiler used by Kennecott. No other major point sources of TSP are thought to be significant in McGill.

5.2.1 Grid System and Equivalent Squares

The grid system used in this inventory covers a 180-km^2 area of the Steptoe Valley between the Egan and Duck Creek Mountain ranges. The gridded area includes both the town of McGill, Nevada, and the Kennecott smelting and milling facilities. The study area has been subdivided into 23 grids. The size of each grid is inversely related to the concentration of human activity in that portion of the valley; i.e., areas of high human activity are divided into a large number of small grids. Figure 5-1 shows the grid system developed for this inventory and the major geographical features of the study area.

The tailings pond is located in the lower center of the grid system. Fugitive emissions from the tailings pond area are

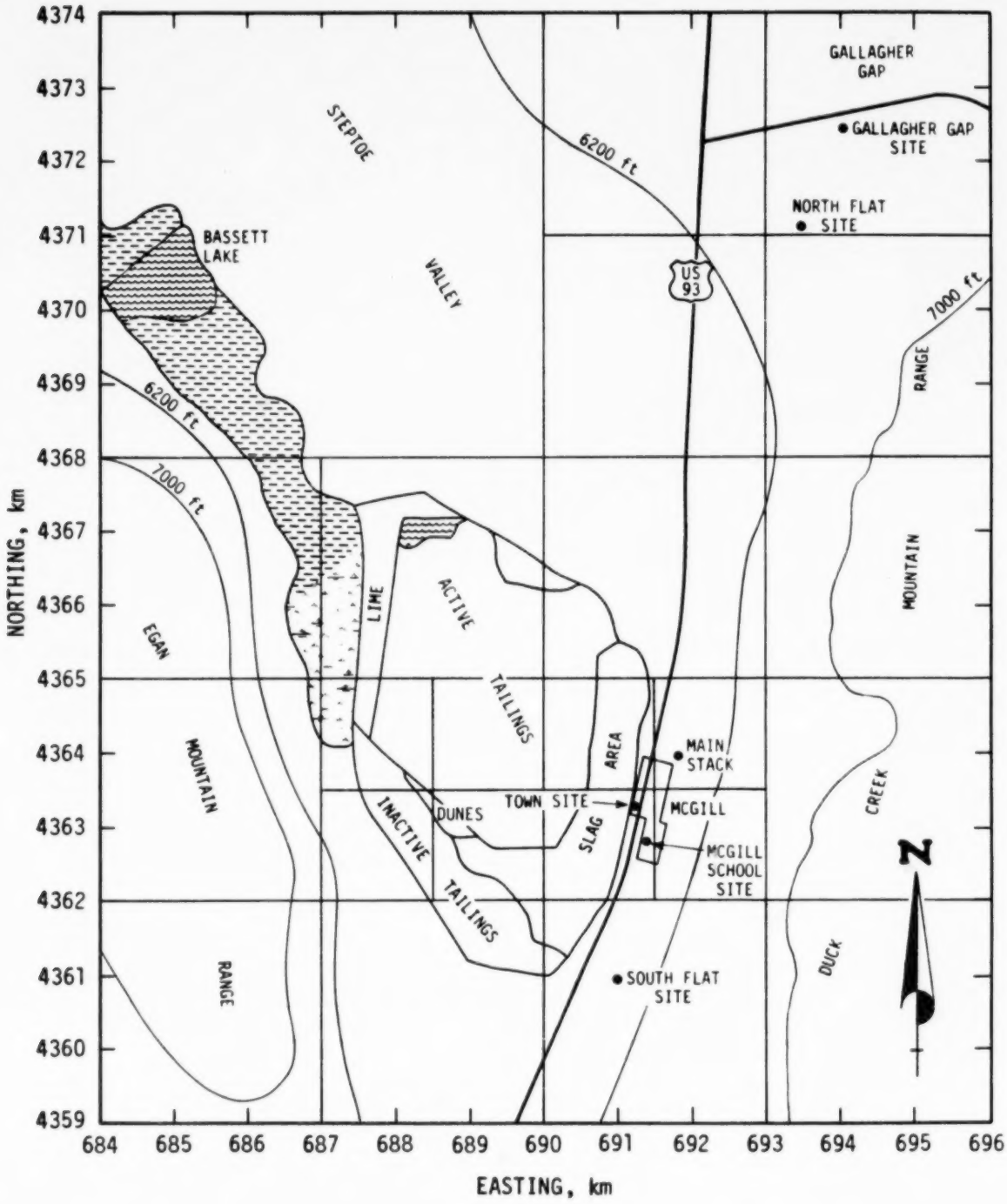

Figure 5-1. Grid system and major geographical features of the study area.

handled separately from other fugitive emissions, such as roadway dust and dust from agricultural tilling. Because the tailings pond is a major area source in the Steptoe Valley, the inventory is designed to allow identification of specific emission sources within the tailings area. These sources include tailings, vegetated areas, dunes, slag cover, lime cover, and furrowed surfaces. The proper treatment of each portion of the tailings pond as a separate, identifiable source requires the conversion of irregular areas of specific portions into equivalent squares. The equivalent squares are entered into the Valley Model as separate area source grids. Figure 5-2 presents the actual configuration of each portion of the tailings pond, and the location and size of its corresponding equivalent square.

The Universal Transverse Mercator (UTM) coordinates of the southwest corner of each area source grid and each portion of the tailings pond are presented in Table 5-1. In addition to the grid and equivalent square locations, the side length of the grid or square and the estimated mean elevation of each surface are provided. The mean elevations are determined from the U.S. Geological Survey (USGS) maps of the study area. The mean elevation is calculated as the average of three point elevations equally spaced on a transect line drawn across the middle of each grid (or equivalent squares). The transect line is drawn in the direction of the slope, or grade of the land.

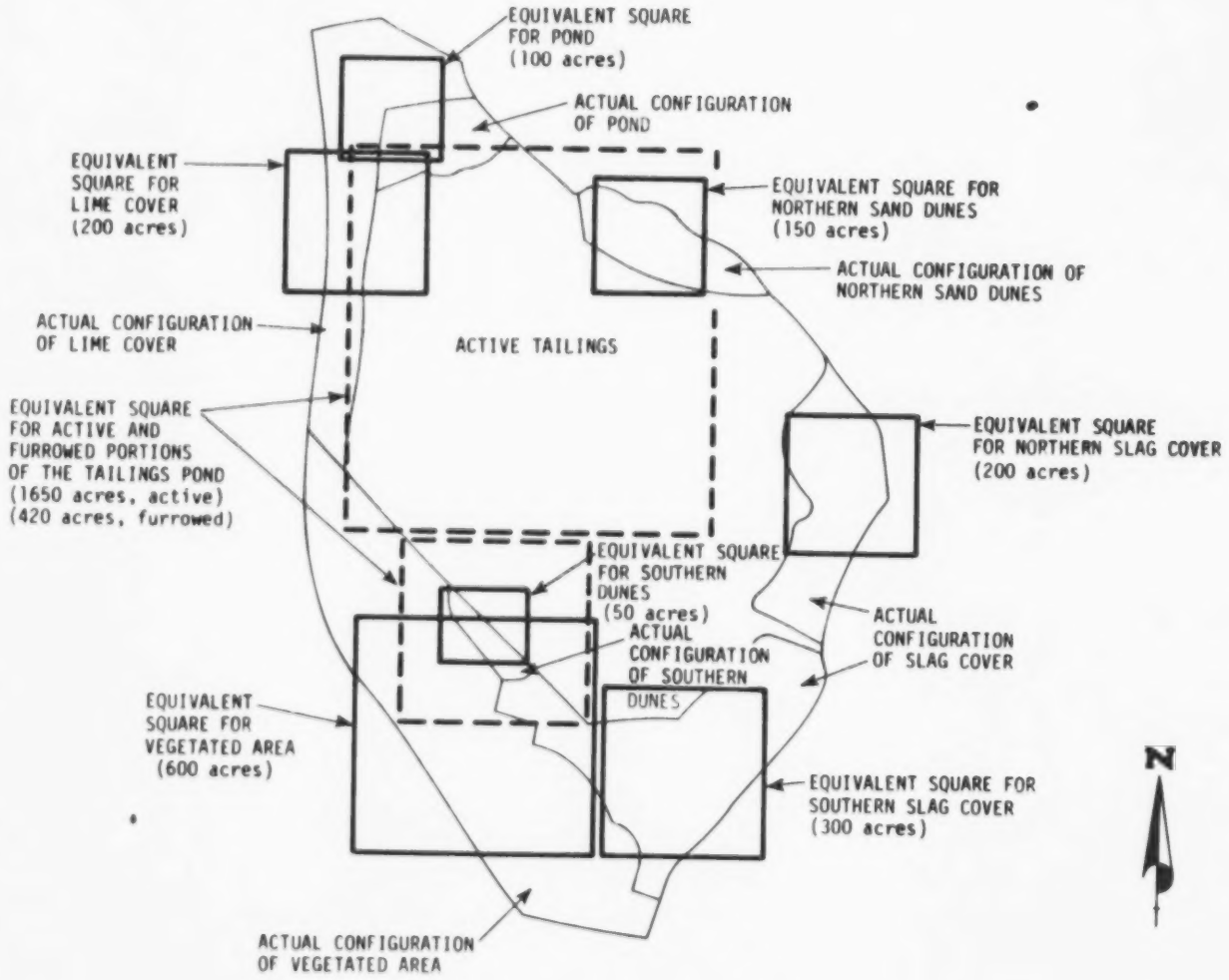
EQUIVALENT SQUARE FOR POND (100 acres)
ACTUAL CONFIGURATION OF POND
EQUIVALENT SQUARE FOR LIME COVER (200 acres)
EQUIVALENT SQUARE FOR NORTHERN SAND DUNES (150 acres)
ACTUAL CONFIGURATION OF NORTHERN SAND DUNES
ACTUAL CONFIGURATION OF LIME COVER
ACTIVE TAILINGS
EQUIVALENT SQUARE FOR ACTIVE AND FURROWED PORTIONS OF THE TAILINGS POND (1650 acres, active) (420 acres, furrowed)
EQUIVALENT SQUARE FOR NORTHERN SLAG COVER (200 acres)
EQUIVALENT SQUARE FOR SOUTHERN DUNES (50 acres)
ACTUAL CONFIGURATION OF SOUTHERN DUNES
ACTUAL CONFIGURATION OF SLAG COVER
EQUIVALENT SQUARE FOR VEGETATED AREA (600 acres)
EQUIVALENT SQUARE FOR SOUTHERN SLAG COVER (300 acres)
ACTUAL CONFIGURATION OF VEGETATED AREA
N

Figure 5-2. Equivalent squares for portions of the Kennecott tailings pond.

TABLE 5-1. GRID AND EQUIVALENT SQUARE LOCATION, SIZE, AND MEAN ELEVATION

Source	UTM coordinates of the southwest corner		Length of side, km	Mean elevation, ft
	Easting, km	Northing, km		
Grid 1	684.0	4308.0	6.0	6100
Grid 2	690.0	4371.0	3.0	6300
Grid 3	693.0	4371.0	3.0	6400
Grid 4	690.0	4368.0	3.0	6200
Grid 5	693.0	4368.0	3.0	7000
Grid 6	684.0	4365.0	3.0	6300
Grid 7	687.0	4365.0	3.0	6100
Grid 8	690.0	4365.0	3.0	6150
Grid 9	693.0	4365.0	3.0	7400
Grid 10	684.0	4363.5	3.0	6400
Grid 11	687.0	4363.5	1.5	6050
Grid 12	688.5	4363.5	1.5	6100
Grid 13	690.0	4363.5	1.5	6200
Grid 14	691.5	4363.5	1.5	6450
Grid 15	693.0	4362.0	3.0	7400
Grid 16	687.0	4362.0	1.5	6150
Grid 17	688.5	4362.0	1.5	6150
Grid 18	690.0	4362.0	1.5	6200
Grid 19	691.5	4362.0	1.5	7600
Grid 20	684.0	4359.0	3.0	6200
Grid 21	687.0	4359.0	3.0	6100
Grid 22	690.0	4359.0	3.0	6600
Grid 23	693.0	4359.0	3.0	7600
Tailings (active)	687.8	4364.3	2.61	6100
Tailings (furrowed)	687.8	4362.9	1.3	6100
Sand dunes (north)	689.2	4365.7	0.78	6100
Sand dunes (south)	688.3	4362.9	0.45	6050
Slag cover (north)	690.5	4363.9	0.90	6150
Slag cover (south)	689.5	4362.0	1.10	6150
Lime cover	687.3	4365.6	0.90	6100
Vegetation	687.8	4361.8	1.56	6050
Pond	687.6	4366.4	0.63	6100

5.2.2 Calculation of Source Strengths and Emissions

Determinations of point and area source emissions require estimates of the strength of each source and the area covered by emissions from each source. Source strength is an estimate of the activity of the emission source during the study time period. The rates of emission are determined by use of standard emission factors and emission factor equations. The resulting emission totals for the McGill study area are presented in Table 5-2.

5.2.2.1 Minor Point Sources--

Minor point sources are stationary combustion sources that emit less than 100 tons of particulates per year. They include residential and commercial home heating sources and small industrial sources. These minor source categories are applied to the McGill study area to cover all stationary combustion sources outside of the Kennecott facility. Stationary source strength is determined from fuel consumption estimates, which are based on fuel usage by housing unit. Equations 1 through 4 present the methods used to determine stationary source consumption of liquified petroleum gas (LPG), distillate oil, coal, and wood in the study area.[1]

$$\text{LPG usage} = 24.1(D_h)(d_h)(R/5.0)(ft^3) \qquad \text{(Eq. 1)}$$

where 24.1 = fuel heating requirement, cubic feet per dwelling-unit-degree-day[1]

D_h = number of dwelling units heated with fuel[2]

d_h = number of heating-degree-days[3]

r = average number of rooms per dwelling unit[2]

5.0 = national average number of rooms per dwelling unit[1]

TABLE 5-2. PARTICULATE EMISSIONS IN THE McGILL STUDY AREA BY SOURCE CATEGORY

Source category	Particulate emissions, tons/yr (% of total)
Residential and commercial LPG	0.06 (<1)
Residential and commercial distillate oil	0.79 (<1)
Residential and commercial coal	6.14 (<1)
Residential and commercial wood	0.70 (<1)
Automotive combustion (on-highway)	7.43 (<1)
Automotive combustion (off-highway)	0.18 (<1)
Locomotive combustion	0.12 (<1)
Residential and commercial waste burning	0.95 (<1)
Structural fires	0.21 (<1)
Agricultural fires	19.50 (<1)
Natural burning, or wildfires	0.00 (0)
Fugitive dust from paved roads	81.26 (<1)
Fugitive dust from dirt and gravel roads	1543.39 (14)
Fugitive dust from agricultural tilling	22.50 (<1)
Windblown fugitive dust from natural and agricultural surfaces	3117.00 (28)
Windblown fugitive dust from the Kennecott tailings pond[a]	6318.00 (57)

[a] See Table 5-7 for a breakdown of the tailings pond emissions.

Distillate oil usage = $0.18\ (D_h)(d_h)(R/5.0)$(gal) (Eq. 2)

where 0.18 = fuel heating requirement, gallons per dwelling-unit-degree-day[1]

D_h = number of heating-degree-days[3]

d_h = number of heating-degree-days[3]

R = average number of rooms per dwelling unit[2]

5.0 = national average number of rooms per dwelling unit[1]

Coal usage = $0.0012\ (D_h)(d_h)(R/5.0)$(tons) (Eq. 3)

where 0.0012 = fuel heating requirement, tons per dwelling-unit-degree-day[1]

D_h = number of dwelling units heating with fuel[2]

d_h = number of heating-degree-days[3]

R = average number of rooms per dwelling unit[2]

5.0 = national average number of rooms per dwelling unit[1]

Wood usage = $0.0017\ (D_h)(d_h)(R/5.0)$(tons) (Eq. 4)

where 0.0017 = fuel heating requirement, tons per dwelling-unit-degree-day[1]

D_h = number of dwelling units heated with fuel[2]

d_h = number of heating-degree-days[3]

R = average number of rooms per dwelling unit[2]

5.0 = national average number of rooms per dwelling unit[1]

The emission factors selected for use with the minor stationary source strengths (fuel consumption) were taken from the U.S. Environmental Protection Agency's "Compilation of Air Pollutant Emission Factors."[4] The vast majority of minor stationary combustion sources in the McGill study are residential or residential-sized space heaters. The emission factors given in Table 5-3 are for residential-sized space heaters.[4,5] The total emissions by residential and commercial source categories for the McGill study area are presented in Table 5-2.

5.2.2.2 Mobile Sources--

Three major types of mobile sources are found in the McGill study area: automotive vehicles on paved highways, automotive vehicles on off-highway surfaces, and diesel locomotives. Although some airplanes fly over the study area (the airport at Ely, Nevada, is southwest of McGill), they account for minimal particulate emissions.

The automotive traffic on paved highways is determined from traffic counts taken by the Nevada State Department of Transportation.[6] The total number of vehicle miles traveled (VMT) per year on paved surfaces in the McGill study area is 13.75 million miles. Based on an emission factor of 1.08×10^{-3} lb/vehicle mile traveled (a value reflecting the composition of the national automotive fleet in 1979),[4] total particulate emissions from on-highway automotive combustion were estimated to be 7.43 tons/yr for the study area (see Table 5-2).

TABLE 5-3. PARTICULATE EMISSION FACTORS FOR MINOR STATIONARY SOURCE COMBUSTION UNITS[4,5]

Fuel	Particulate emission factor in all study years
Natural and liquid petroleum gas[a]	5.0 lb/10^6 ft^3
Distillate oil	10.0 lb/10^3 gal
Bituminous coal[b]	2.0 lb/ton
Wood	17.0 lb/ton

[a] Particulate emissions from combustion of natural gas range from 5 to 15 lb/10^6 ft^3, depending on the design of the combustion unit and amount of contaminants in the fuel. Liquified petroleum gas is considered a "clean" fuel because it does not produce visible emissions. The factor of 5 lb/10^6 ft^3 of gas is considered a reasonable estimate of particulate emissions from sources firing natural gas and LPG.

[b] The ash content is estimated to be 12 percent (i.e., the average content of western coal.

Major automotive off-highway combustion sources found in the McGill area include gasoline-powered off-road vehicles, gasoline- and diesel-powered tractors, and an assortment of special-purpose and utility equipment (e.g., chain saws and electrical generators).

An accurate estimate of the number of off-road vehicles using the McGill study area is impossible. The number of miles traveled by such vehicles, however, is small compared with the total number of miles traveled by on-highway vehicles.

The use of gasoline- and diesel-powered tractors in the study area, although quite small, is easy to estimate from county-wide vehicle registrations.[7] The amount of agricultural land under cultivation indicates that approximately 5.4 tractors operate in the gridded study area. Using the ratio of gasoline- to diesel-powered tractors in White Pine County, one can estimate that 2 tractors use diesel fuel and 3.4 tractors use gasoline. Roughly 3400 gal of gasoline and 2000 gal of diesel fuel are consumed each year by these off-highway sources. These values are calculated by assuming that the annual fuel consumption rate for gasoline- and diesel-powered tractors is 1000 gal/yr.[1] Based on particulate emission rates of 8.0 $lb/10^3$ gal of gasoline and 45.7 $lb/10^3$ gal of diesel fuel,[4] particulate emissions from tractors in the study area total 0.06 ton/yr.

The special-purpose equipment used in the study area is estimated to consume 9768 gal of gasoline per year. This value is based on a population of 1320 persons[2] and fuel usage of 7.4

gal per person per year.[4] The emission rate for small gasoline-powered equipment is 25.0 lb/10^3 gal per year.[4]

Total particulate emissions from off-highway automotive combustion are estimated to be 0.18 ton per year (see Table 5-2). This estimate is based upon emission rates of 0.06 ton per year for agricultural tractors and 0.12 ton per year for small gasoline engines.

Locomotive activity was determined by measuring the miles of main railroad track in the study area. Track mileage in the study area was determined from USGS maps to be 24.5 miles. Based on this value along with the statewide figure of 1504.2 miles for main line track,[8] a ratio was developed to apportion the state figure for locomotive fuel consumption.[9] The locomotive fuel usage for the study area was estimated to be 9990 gal/yr. Given an emission factor for diesel locomotive engines of 25 lb/10^3 gal,[4] total particulate emissions from locomotives were calculated to be 0.12 ton per year.

5.2.2.3 Open-Burning Sources--

The open-burning category includes combustion of residential and commercial wastes, structural fires, agricultural burning, and natural burning (or wildfires). Altogether, open-burning sources in the study area are estimated to emit 20.66 tons of particulates per year.

Combustion of residential and commercial waste material produces 0.95 ton of particulates per year. This figure is

based upon a waste generation rate of 0.09 ton per capita/year,[1] a study area population of 1320 individuals,[2] and an emission factor of 16.0 lb of particulates per ton of waste material consumed.[4]

Structural fires are expected to generate an average of 0.21 ton of particulates per year. This emission rate is based upon an annual frequency of four fires per thousand individuals,[1] an estimated consumption rate of 5.0 tons of combustible material per fire, and an emission factor of 16.0 lb of particulates per ton of combustible material.[4]

Agricultural burning in the study area is expected to produce 19.5 tons of particulates per year. This is based upon a 1:1:1 crop ratio of alfalfa, hay, and unspecified grasses; and a combined emission rate of 27.8 lb/acre per year.[4] Roughly 1400 acres, or one-half of the cultivated land, is expected to be burned.[10]

Natural burning (or wildfires) is not considered a source of particulate emissions. The U.S. Forest Service[11] indicated that no wildfires occurred in the study area during the study year.

5.2.2.4 Fugitive Dust Sources--

The major fugitive dust sources found in the McGill study area are paved roadways, gravel roadways, dirt roads, agricultural tilling, and windblown emissions from exposed land surfaces. Fugitive sources were located by the use of USGS maps and an onsite survey of the study area.

Automotive activities on paved roads produce 81.26 tons of fugitive emissions per year. This emission rate is based upon an activity level of 13.75 million VMT and an emission rate of 0.012 lb/vehicle mile.[4]

Automotive activities on dirt and gravel roads generate 1543 tons of fugitive emissions per year. This emission rate is based upon an activity level of 99,480 VMT for dirt roads and 259.8 VMT for gravel roads. The study area contains approximately 136 miles of dirt roads; two vehicles on average were assumed to travel these roads each day. The study area also contains 26 miles of gravel roads; an average daily traffic volume of 10 vehicles was assumed on these roads. Equation 5 was used to determine emission factors for fugitive emissions from dirt and gravel roads.[4]

$$E = (0.81\ s)(S/30)(P)\left(\frac{n}{4}\right) \qquad \text{(Eq. 5)}$$

where E = corrected emission factor, pounds per vehicle mile

s = silt content of road material, percent

S = average speed of vehicle, miles per hour

P = precipitation factor

n = average number of wheels per vehicle

The values of variables used to estimate fugitive emission factors for dirt and gravel roadways are given in Table 5-4.

TABLE 5-4. VARIABLES USED TO ESTIMATE EMISSION FACTORS FOR FUGITIVE DUST FROM DIRT AND GRAVEL ROADWAYS

Variable	Dirt road on piedmont slope	Dirt road on valley floor	All gravel roads
Silt content, %	24	63	12
Average vehicle speed, mph	20	20	50
Average number of wheels per vehicle	4	4	4
Precipitation factor[a]	0.8	0.8	0.8
Corrected Emission Factor (lb/VMT)	10.4	27.2	13.0

[a]Equals (365 - W)/365, where W is the number of days with 0.01 inch or more of rainfall. In the Steptoe Valley, W is 72.

Agricultural tilling generates an estimated 22.50 tons per year of fugitive emissions. This is based upon one tilling operation per year on 10 percent (or 313.5 acres) of the agricultural land.[10] An emission factor for fugitive dust from agricultural tilling was determined by use of Equation 6.[4]

$$E = [1.4s/(PE/50)^2] \ (P) \ (N) \qquad \text{(Eq. 6)}$$

where E = corrected emission factor, pounds per acre

s = silt content of surface soil, 30 percent is the value for the percent; Valley Basin[12]

PE = Thornthwaite's precipitation-evaporation index; 27 is the value for eastern Nevada[13]

P = precipitation factor; 0.8 is the study area value (see Table 5-4)

N = number of tilling and harrowing operations per year; 1 is the study area value[10]

The emission factor for agricultural tilling operations in the Steptoe Valley was calculated to be 144.0 lb per acre.

Windblown fugitive dust comes from three major types of exposed surfaces in the study area: natural surfaces covered by wild vegetation, agricultural surfaces, and tailings pond surfaces. Natural and agriculture surfaces generate 3117 tons of fugitive emissions per year. Although this figure may seem large at first glance, it is based on a daily emission rate of less than 0.5 g/m^2; the study area covers 180 km^2. The actual emission factors used for determining fugitive dust from natural and agricultural surfaces were developed from the following equation:[13]

$$E = (k)(I)(K)(C)(L')(V')(P)(Cr) \qquad \text{(Eq. 7)}$$

where E = emission factor, tons per acre

k = proportionality factor for particles with potential for long-range transport; 0.025.[13]

I = soil erodibility, tons per acre[13]

K = surface roughness factor[13]

C = climatic factor[13]

L' = unsheltered field width factor[13]

V' = vegetative cover factor[13]

P = precipitation factor

Cr = crusting factor, 0.16[14]

Table 5-5 shows the values used for the above variables.

Equation 7 was also used to estimate windblown fugitive emissions from tailings pond surfaces. Table 5-6 presents the values used in Equation 7 to make the estimate, and Table 5-7 summarizes information about windblown fugitive emissions from areas within the Kennecott tailings pond. An average annual windspeed of 11 mph was derived from the National Weather Service data at the Ely, Nevada airport. Altogether, areas within the tailings pond generate approximately 6318 tons per year of fugitive particulates.

5.2.3 Major Point Sources

The only major point sources in this analysis are the main stack and the small boiler on the smelter property. Table 5-8 presents stack parameters and emission rates for these sources; the most recent Kennecott estimates for the McGill Smelter are used. Emission rates are based on estimates of

TABLE 5-5. VALUES USED TO ESTIMATE EMISSION FACTORS FOR WINDBLOWN FUGITIVE DUST FROM NATURAL AND AGRICULTURAL SURFACES

Land surface	Vegetation	Soil erodibility (I),[a] tons/acre	Surface roughness factor (K)[b]	Climatic factor (C)[c]	Unsheltered field width factor (L')[d]	Vegetative cover factor (V')[e]	Precipitation factor (P)	Crusting factor (Cr)[f]	Emission factor (E), tons/acre
Mountain	Pinyon-juniper forest	22	0.9	0.63	0.5	0.35	0.8	0.16	0.01
Valley	Sagebrush, winterfat, annuals, etc.	220	1.0	0.63	1.0	0.24	0.8	0.16	0.11
Agricultural	Alfalfa	86	1.0	0.63	0.95	0.0	0.8	1.0	Neg.
	Hay	86	0.8	0.63	0.88	0.13	0.8	1.0	0.03
	Grasses	86	0.6	0.63	0.84	0.0	0.8	1.0	Neg.

[a] Mountain soils are considered low in fine particles because of the steep slope of the land and the past erosion of silt into the valley basin;[12] the soil particles are considered to be >0.84 mm in diameter. An assumed factor of 0.1 was used to estimate I from the erodibility factor for sand (220). Valley soils, which are considered to be very high in fine particles,[12] were assigned an erodibility factor of 220. Sandy loam soil with an erodibility factor of 86 was selected for all agricultural surfaces.[13]

[b] Minimal reduction was assumed for the rocky (mountain slope) surfaces; no reduction was assumed for the smooth open plain of the valley floor; and variable reductions were assumed for the agricultural crops, depending upon the extent of land preparation.

[c] Equals $0.345\ (W^3/PE^2)$, where W is the annual average windspeed (i.e., 11 mph)[3] and PE is the precipitation-evaporation index in eastern Nevada (i.e., 27).[13]

[d] A value of 0.5 was assumed for mountain surfaces because of the sparse nature of pinyon-juniper forests. Maximum field lengths were assumed for other types of vegetation.[13]

[e] Cover by a pinyon-juniper forest was assumed to be limited, and cover by sagebrush was estimated to be similar to cover by agricultural grasses. Values for cover by agricultural crops were taken from Reference 13.

[f] A five-sixth reduction was assumed for natural crusting of soil surface.[14]

TABLE 5-6. VALUES USED TO ESTIMATE FACTORS FOR WINDBLOWN FUGITIVE DUST FROM THE KENNECOTT TAILINGS POND

Tailings surface	Control measure	Soil erodibility (I),[a] tons/acre	Surface roughness factor (K)[b]	Climatic factor (C)[c]	Unsheltered field width factor (L')[d]	Vegetative cover factor (V')[d]	Precipitation factor (P)[e]	Crusting factor (Cr)[f]	Control measure reduction factor (Cm)[g]	Emission factor (E), tons/acre
Active tailings	None	220	1.0	0.63	1.00	1.00	0.8			2.78
Furrowed tailings	Furrowing and irrigation	220	1.0	0.63	1.00	1.00	0.8	0.8	0.94	0.52
Sand dunes (north)	None	220	1.0	0.63	1.00	1.00	0.8			2.78
Sand dunes (south)	None	220	1.0	0.63	0.98	1.00	0.8			2.73
Slag cover (north)	Iron slag	49	1.0	0.63	0.90	1.00	0.8			0.56
Slag cover (south)	Iron slag	49	1.0	0.63	0.90	1.00	0.8			0.57
Lime cover	Lime slurry	220	1.0	0.63	0.88	0.99	0.8	0.8		0.48
Vegetative cover	Natural vegetation	220	0.9	0.63	1.00	0.33	0.8			0.83
Pond area	Water									0.00

[a] The soil erodibility factor for the tailings is based upon a particle size fraction (>0.84 mm) of less than 1 percent. This was determined from a grab sample of the active tailings.[15] The slag cover erodibility index is based upon a 22 percent reduction in the silt content of slag as compared with sand, expressed as a reduction ratio (R), where R is the silt content of slag divided by the silt content of tailings. Silt content of iron slag was determined to be 0.02 percent,[16] and the silt content of sand was determined to be 0.09 percent.[17]

[b] Values of 1.0 indicate no significant reduction of wind erosion because of surface roughness; the vegetative cover factor is based on a minimal amount of reduction because of initial soil preparation before planting.

[c] Equals $0.345(W^3/PE^2)$, where W is the annual average windspeed (i.e., 11 mph)[3] and PE is the precipitation-evaporation index in eastern Nevada (i.e., 27).[13]

[d] Reference 13.

[e] Equals (365-P)/365, where P is the number of days of precipitation. In this study area P is equal to 73 days.

[f] A five-sixth reduction was assumed for natural crusting of soil surface.[14]

[g] Equals (365-I/365, where I is the number of days of irrigation. In the study area, I is approximately 21 days.[18]

TABLE 5-7. WINDBLOWN FUGITIVE EMISSIONS FROM THE KENNECOTT TAILINGS POND

Tailings surface	Surface area, acres	Emission factor, tons/acre per yr	Emissions, tons/yr
Active tailings	1680	2.78	4670
Furrowed tailings	420	0.52	219
Sand dunes (north)	150	2.78	417
Sand dunes (south)	50	2.73	136
Slag cover (north)	200	0.56	114
Slag cover (south)	300	0.57	168
Lime cover	200	0.48	96
Vegetative cover	600	0.83	498
Pond	100	0.00	0
Total	3700		6318

TABLE 5-8. STACK PARAMETERS AND PARTICULATE EMISSION RATES FOR THE MAIN STACK AND SMALL BOILER

Main stack	
Stack height	229 m
Stack diameter	4.7 m
Gas exit velocity	21.2 m/s
Gas temperature	422K
Emission rate[a]	259.20 g/s
Small boiler	
Stack height	32 m
Stack diameter	2.1 m
Gas exit velocity	2.1 m/s
Gas temperature	300K
Emission rate[a]	15.13 g/s at 25% capacity

[a]Emission rates are maximum hourly actual emissions assumed to occur at least 6 hours per day.

worst-case or maximum short-term release to maximize the 24-hour ambient concentrations.

The locations of the stacks are given in UTM coordinates in Section 1. The distance between them is roughtly 210 meters.

Fugitive emissions are released from the smelter at a height of 45 meters. The area width for smelter fugitives is 300 meters, and the emission rate is 90.71 g/s. No refinement of the smelter fugitives was attempted in this analysis because of the uncertainty in temporal and spatial characterization. The emissions were characterized as in previous Kennecott analyses.

5.2.4 Appropriateness of Emission Estimates

The emission estimates were based on the best data available at the time of the inventory. Particular emphasis was placed on trying to define as much of the tailings pond area as was possible. Grab samples of the tailings pond surface and sand dunes were made to ensure an adequate estimate of aggregate content for these sources.[15] The mean silt content of the Valley soils was estimated from regional data available from the University of Nevada at Reno.[12] Surface erosion, windspeed, precipitation, and other factors were considered in estimating emissions (see Tables 5-4, 5-5, and 5-6). When emission factors had to be tailored for specific areas (e.g., portions of the tailings pond, agricultural land, and natural surfaces), attempts were made to obtain specific data; when specific data were unavailable, assumptions were made on the basis of onsite survey results.

Main stack particulate emissions are based on stack sampling under typical load conditions and represent maximum measured hourly releases. Smelter fugitives are considered to be 35 percent of the main stack release. The estimated rate of emissions from the small smelter boiler is based on coal usage at 25 percent load condition; according to Kennecott personnel, this represents the maximum load the boiler experiences in any 24-hour period.

5.3 MODELING METHODOLOGY AND RESULTS

5.3.1 Overview

Two Valley Model applications are addressed in this analysis: an annual average concentration estimate and a 24-hour estimate. Source contributions for each application are presented.

The 24-hour averaging analysis is performed in the same way as the analysis in Section 2. The annual average concentration methodology, however, differs to some degree from previous Valley modeling. In this study, emission estimates from each area or fugitive source are treated as a function of windspeed. Using an emission rate based on the annual average windspeed would have overestimated emissions for low windspeeds and underestimated them for high windspeeds. Instead, area emissions were adjusted for the central windspeed of each STAR windspeed class (i.e., 0.67, 2.45, 4.47, and 6.93 m/s and greater). The class of windspeeds greater than 6.93 m/s is thought to be representative of higher windspeeds.

Only that portion of each total fugitive source that is dependent upon the wind is affected. Some sources of particulate emissions (e.g., vehicles on unpaved roads or agricultural tilling) are only partially affected by the windspeed changes. Other sources (especially the tailings pond) are dependent solely upon windblown emissions.

For each climatological weighting factor (STAR) applied to the basic Valley dispersion calculations, an associated emission factor is applied. This procedure results in a more refined treatment of windblown sources and accounts for the variable background concentrations. Because annual particulate emissions from the main stack and small boiler and emissions from the fugitive smelter were not estimated, the maximum 24-hour emissions were used in the annual analysis. Because the plant does not operate at maximum load every day for a whole year, concentration estimates for the annual averages are expected to be very conservative.

5.3.2 Annual Average Concentration Estimates

Current estimates of annual average concentrations are similar to previous estimates. Fugitive emissions from the smelter are the main contributor to most estimated violations of the NAAQS for TSP; concentration estimates are extremely conservative because maximum emissions are assumed for the major emitters. The main stack does not contribute significantly to the receptors near the smelter (within 0.9 km of the stack) even under these very high emission scenarios, but may contribute to

the annual concentrations estimated at maximum terrain impact locations (i.e., to the southeast, east, and northeast of the smelter on the mountains). Table 5-9 presents the annual average TSP concentrations at each receptor. Estimates include emissions from all sources. Because of the prevailing north-south wind flow and terrain impact east of the plant, receptors in these areas generally have the highest concentrations.

Under the annual TSP NAAQS of 75 $\mu g/m^3$ (geometric mean), 36 excursions may be expected each year. As with previous EPA modeling, no monitors are located exactly where the Valley Model predicts annual average violations to occur. No measured TSP violations for annual average have been found, and no violations of annual standards are expected to occur because overly conservative major source emissions are used. The analysis is useful from the standpoint of providing a source contribution table for critical receptors and indicating potential tailings pond and other fugitive particulate emissions.

Table 5-10 illustrates the contributions of various sources to TSP levels at the five receptors with highest annual average concentrations. Area Sources 1 through 23 make fairly consistent contributions of 10 to 20 $\mu g/m^3$. These sources probably represent background TSP because they generally emit some TSP under all meteorological conditions on an annual basis. Contributions from the main stack are negligible, even with artificially high estimates used in this analysis. The small boiler, however, contributes 11 to 16 percent of total estimated concentration at each receptor. The tailings pond does not contribute more than

TABLE 5-9. ANNUAL AVERAGE TSP CONCENTRATIONS[a] ($\mu g/m^3$)

Direction	Ring[b]						
	1	2	3	4	5	6	7
N	161	118	95	89	85	81	79
NNE	183	135	167	115	81	82	73
NE	396	141	79	57	84	58	50
ENE	206	80	95	54	51	26	23
E	178	112	79	44	25	20	17
ESE	175	57	66	51	25	22	18
SE	218	118	88	69	45	28	22
SSE	231	89	83	51	41	40	30
S	258	126	77	52	41	34	36
SSW	119	69	63	44	37	32	28
SW	81	63	55	45	39	38	33
WSW	83	61	55	53	58	40	28
W	77	58	75	77	54	28	23
WNW	71	57	96	105	87	52	22
NW	69	68	92	118	101	77	66
NNW	137	82	79	94	92	87	78

[a]Values are high because maximum 24-hour emissions from the main stack and small boiler and maximum 24-hour fugitive emissions are assumed to occur throughout a whole year.

[b]Because rings are not round, only a ring number is given. Each successive ring is approximately 0.8 km further from the center of the coordinate system.

TABLE 5-10. SOURCE CONTRIBUTIONS TO TSP LEVELS AT THE FIVE RECEPTORS WITH HIGHEST ANNUAL AVERAGE TSP CONCENTRATIONS

Receptor rank	1	2	3	4	5
Direction to receptor	NE	S	SSE	SE	ENE
Distance to receptor, km	0.67	0.78	0.69	0.67	0.81
Total concentratation, $\mu g/m^3$	396	258	231	218	206
Concentration contribution, (percent of total) $\mu g/m^3$					
Main stack	0.0 (0)	0.1 (<1)	0.0 (0)	0.0 (0)	0.0 (0)
Small boiler	44.7 (11)	42.2 (16)	32.2 (14)	31.3 (14)	30.3 (15)
Area sources 1 through 23	16.6 (4)	16.4 (6)	20.7 (9)	15.5 (7)	9.2 (4)
Smelter fugitives	316.8 (80)	184.3 (71)	165.1 (71)	158.4 (73)	152.8 (74)
Active tailings	10.8 (3)	9.4 (4)	8.0 (3)	8.0 (4)	8.7 (4)
Furrowed tailings	0.7 (<1)	0.5 (<1)	0.5 (<1)	0.5 (<1)	0.6 (<1)
Dunes	1.9 (<1)	1.7 (1)	1.6 (1)	1.5 (1)	1.5 (1)
Slag	4.0 (1)	2.9 (1)	2.4 (1)	2.3 (1)	2.5 (1)
Other tailings	0.5 (<1)	0.5 (<1)	0.5 (<1)	0.5 (<1)	0.4 (<1)

7 percent of the total concentration at any of the five receptors. Most particulates at the receptors are smelter fugitives, which contribute significantly to particulate concentrations within 2 km of the smelter. Receptors beyond 2 km are affected mainly by particulates from the main stack, the tailings pond, and other area sources. Because no annual average violations have been measured at the McGill School or Townsite monitors, both of which are in the vicinity of the maximum estimated concentrations, the maximum estimates of smelter fugitives are assumed to be overly conservative. Further, this analysis indicates minimal impact from the main stack and the tailings pond.

5.3.3 Short-Term 24-Hour Concentrations

All of the 24-hour estimated TSP concentrations given in Section 2 reflect only the impact of the main stack, the smelter fugitives, and the overall tailings pond emissions. As with the analysis of annual average estimates, a new Valley Model analysis was performed with the improved inventory of particulate emissions.

Table 5-11 presents the maximum expected 24-hour concentrations in Valley Ring 1. The distance from the main stack to the first ring is 0.5 to 0.8 km. Near neutral conditions (C stability) are assumed with windspeeds of 6.67 m/s (15 mph) for at least 6 hours in the receptor directions indicated. Compared with the annual averages in Tables 5-9 and 5-10, these 24-hour concentrations appear very low. These tables, however, should not be compared and should not be construed to represent worst case ambient air quality. The annual averages in Tables 5-9 and

TABLE 5-11. 24-HOUR TSP CONCENTRATIONS IN VALLEY RING 1[a]

Receptor direction	Total concentration, $\mu g/m^3$
N	97
NNE	104
NE	106
ENE	101
E	109
ESE	112
SE	111
SSE	112
S	108
SSW	154
SW	90
WSW	81
W	83
WNW	81
NW	75
NNW	95

[a]The distance from the main stack to the first ring is about 0.5 to 0.8 km; C stability and windspeeds of 6.67 m/s (15 mph) are assumed.

5-10 were calculated using maximum short-term emissions and consequently were overly conservative. On the other hand, Table 5-11 presents concentration estimates that appear low; maximum particulate emissions from the main stack and small boiler and fugitive emissions from the smelter are reasonable because these are maximum short-term emission estimates. Also, because the tailings pond emissions are a function of windspeed, at the assumed windspeed of 6.67 m/sec emissions were fairly high. These winds occur reasonably often (∿5% of the time) near McGill. Since concentrations are inversely proportional to windspeed in the Valley Model, estimated concentrations due to the main stack, the boiler, and the smelter fugitives are reduced at high windspeeds. Concentration estimates in the 24-hour analysis reflect an attempt to maximize tailings pond contributions and the combined impacts of the tailings pond and main stack in the Valley. The maximum impact of the main stack under these conditions is 5.0 km downwind in flat terrain (i.e., near the North Flat site). At lower windspeeds and more stable conditions higher impacts from the main stack and smelter fugitives may be estimated, as seen in Section 2; but tailings pond contributions are minimal under these conditions. Thus, the analysis used to derive Table 5-11 relies on meteorological and emission assumptions that maximize overall tailings pond and area source emissions.

The Valley Model results indicate that the maximum 24-hour impact of the main stack occurs 5.0 km downwind and equals approximately 8.0 $\mu g/m^3$ of TSP in all directions. The Valley

Model does not consider the effects of complex terrain for any of the unstable cases. As a result, estimated concentrations are nearly the same in each direction. As with previous modeling, all the highest 24-hour TSP concentrations occur within 0.5 to 0.8 km of the smelter and are primarily caused by smelter fugitives. One receptor to the south-southwest of the smelter is estimated to exceed slightly the secondary national ambient TSP standard (150 $\mu g/m^3$). This receptor is situated within 0.3 km of the small smelter boiler, and smelter fugitives may account for the high concentration there. Even at high windspeeds, smelter fugitives (which in this study are not dependent on windspeed) contribute to the maximum estimated concentrations.

The maximum impact of tailings is immediately adjacent to or downwind of the tailings pond. This analysis attributes no excursions of TSP standards to the tailings pond. Maximum contributions range from 20 to 40 $\mu g/m^3$ to the north of the tailings pond.

No other 24-hour analyses were conducted with the updated inventory. Conditions leading to maximum main stack impacts and smelter fugitive impacts (i.e., A, E, and F stabilities with light winds) would produce TSP concentrations similar to those generated in Section 2, because tailings pond emissions are very low under these conditions. Although this updated inventory does not eliminate the possibility of 24-hour violations at varying atmospheric conditions, it shows that in general tailings pond emissions will not cause violations of NAAQS except possibly at extreme windspeeds (i.e., windspeeds much greater than 15 m/s).

The small boiler, which was not considered in the previous EPA and Kennecott analysis, contributes significantly to TSP concentrations at nearby receptors under certain conditions. Screening analysis indicates that the maximum impact of this boiler stack occurs 0.5 to 0.8 km downwind at neutral stability and light windspeed. Thus, a complete analysis of all stabilities and wind conditions will probably show 24-hour concentrations similar to those derived in the above analysis. The annual average estimate will be smaller when emissions are adjusted for actual operating loads and hours.

The contribution of smelter fugitives to TSP levels at receptors near the smelter will increase at lower windspeeds because the fugitives do not depend on windblown emission factors. No better emission factors for the fugitives are currently available. Such factors are extremely difficult to estimate because of the changing character and temporal and spatial variability of fugitives. Consequently, 24-hour modeling suggests that smelter fugitives nearly always contribute high concentrations of TSP to nearby receptors. The actual amount of smelter fugitives released over a year, however, is smaller than 24-hour modeling indicates.

5.3.4 Height of the Main Stack

Up to this point the McGill Smelter has received full stack height credit for the purposes of dispersion modeling. According to current good engineering practice (GEP) policies, however, this smelter should only receive credit for GEP determined stack

height or the taller of the two grandfathered stacks. Dispersion analysis of the main stack with only GEP stack height (i.e., 104 meters, the height of the taller grandfathered stack) indicates that maximum impact occurs to the east-southeast of the stack at 0.66 km downwind on the nearby mountainside. Consistent parameters used in previous modeling are used to estimate a maximum TSP 24-hour concentration with the Valley Model. The maximum 24-hour concentration estimated is 2959 $\mu g/m^3$, caused solely by the main stack.

5.4 SUMMARY

A more detailed area source and fugitive emission inventory has been assembled. Also, a small boiler on the smelter property has been added to the original EPA and Kennecott Valley Model analysis. For the most part, the area sources (other than the tailings pond) account for the background concentrations that were initially assumed. Thus modeling verifies the EPA and Kennecott background values. The breakdown of the tailings into subsources indicates that the active tailings emit more particulates than other subsources. Particulate emissions from the main stack and fugitive emissions from the smelter contributed to concentration estimates in the same way as in previous modeling. The main stack affects nearby terrain and has little impact on close-in receptors, and smelter fugitives affect close-in receptors significantly. The effects of the small boiler stack on close-in receptors may be significant. Under grandfathered

stack height constraints, particulate emissions from the main stack are estimated to increase TSP concentrations in the nearby mountain terrain by 65 percent.

REFERENCES FOR SECTION 5

1. U.S. Environmental Protection Agency. Guide for Compiling a Comprehensive Emission Inventory. 2nd ed. APTD-1135, 1974.

2. U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census. Detailed Housing Characteristics, Nevada. Washington, D.C. 1970.

3. National Oceanic and Atmosphere Administration. Local Climatological Data: Annual Summary With Comparative Data. National Climatic Center, Asheville, North Carolina, December 1978-November 1979.

4. U.S. Environmental Protection Agency. Compilation of Air Pollution Emission Factors. AP-42, 1979. Supplements 1-9.

5. Combustion Engineering, Inc. Handbook. Windsor, Connecticut, 1970. p. 32.

6. Planning Division, Department of Transportation. 1979 Annual Traffic Report - Nevada Highways. Carson City, Nevada, 1979.

7. Department of Conservation and Natural Resources. White Pine County Emissions Inventory. Carson City, Nevada, 1978.

8. Planning Division, Department of Transportation. Nevada State Rail Plan. Carson City, Nevada, 1978.

9. Department of Energy, Energy Information Administration. Energy Data Reports: Sales of Fuel Oil and Kerosene, 1978. Washington, D.C., 1979.

10. Personal communications between L. Ungers, PEDCo Environmental, Inc., and White Pine County Agricultural Extension Service, Ely, Nevada. July 9, 1980.

11. Personal communication between L. Ungers, PEDCo Environmental, Inc., and S. Swanson, Elko, Nevada. July 9, 1980.

12. Personal communication between L. Ungers, PEDCo Environmental, Inc., and F. Peterson, University of Nevada, Reno, Nevada. July 25, 1980.

13. U.S. Environmental Protection Agency. Development of Emission Factors for Fugitive Dust Sources. EPA-450/3-74-037, June 1974.

14. PEDCo Environmental, Inc. Nevada Particulate Control Study for Air Quality Maintenance Areas. Prepared for the U.S. Environmental Protection Agency. Cincinnati, Ohio, March 1977.

15. Ungers, L. J. Tailings Sample and Particle Size Analysis. PEDCo Environmental, Inc., Cincinnati, Ohio, August 1980.

16. Bohn, R., et al. Fugitive Emissions From Integrated Iron and Steel Plants. EPA-600/2-78-050, March 1978.

17. Chepil, W. S. Soil Conditions That Influence Wind Erosion. U.S. Department of Agriculture, Washington, D.C., 1958. Bulletin 1185.

18. Personal communications between L. Ungers, PEDCo Environmental, Inc., and William G. Miles, Kennecott Minerals Company, McGill, Nevada. August 16, 1980.

SECTION 6

REVIEW OF THE HYDRODYNAMIC MODEL

The objective of this section is to review the Hydrodynamic Model of INTERA, Inc., for the appropriateness of its application to the McGill Smelter. Appropriateness will be defined in terms of model applicability, evaluations performed using field data, limitations, and model use (and subsequent interpretation of results). Other names that the model has been identified by include INTERA Model, INTERCOMP Model, and most recently the Modified Potential Flow - Turbulent Diffusion (MPF-TD) Model. Throughout the remainder of this review, the model will be called MPF-TD.

This review is limited to summarizing the limitations, advantages, reasonableness, and evaluations found in the published reports of EPA, Kennecott, and other organizations. No specific review is presented that investigates the basis for equations chosen, their boundary conditions, solutions, or the selection of empirical factors. This type of review has been summarized to some extent by Koch.[1]

The following sections present a brief qualitative overview of MPF-TD, a summary of previous model evaluations, limitations and caveats, a review of the applications to McGill, and recommendations and conclusions.

6.1 MODEL OVERVIEW

The MPF-TD Model is a numerical solution of the three-dimensional material balances for the entire air stream and the pollutant flowing within that airstream. The model developed by INTERA Environmental Consultants[2] is a combination of modified potential flow and turbulent diffusion. Classical potential flow theory as applied to fluid motion is a simplification that assumes a flow is inviscid, nonturbulent, irrotational, incompressible, and homogeneous and requires only the solution of the mass continuity equation. To account for flow over terrain and for vertical suppression of the mean flow in a stable atmosphere, the velocity potential is modified to include a height-dependent, empirical flow coefficient. This empirical modification causes calculated windspeed to vary with height. The result is a terrain-induced wind field that is used in the solution of the diffusion equation.

The material balance for a pollutant advecting and diffusing in the flow field is calculated by turbulent diffusion equations that approximate turbulent fluctuations by a Fickian-type eddy diffusion model. The eddy diffusivity used in the model is height-dependent and consistent with both turbulent fluctuation measurements and theory.[3]

In all, six empirical coefficients are required to complete a solution of MPF-TD and to calculate concentrations. These factors define (1) the boundary layer thickness, (2) the power law variation of wind velocity with height as functions of

stability, (3) the stability-dependent degree of suppression on vertical flow, and (4) the degree of diffusivity. The coefficients are estimated from available field and laboratory experiments.[4]

Generally, the MPF-TD Model is applicable in flat terrain monitoring and yields results similar to those of the standard Gaussian models. More specifically, the model is applicable to rough terrain modeling and has been extremely useful in assessing theoretical pollutant transport over mountainous terrain. The model is limited in its present form, however, in that it prevents the formation of recirculating flow on the windward or lee side of a terrain feature or obstacle. Also, because of the elimination of the energy balance equation, the effects of material convective flows cannot be estimated (e.g., mountain drainage winds and lake and sea breezes).[1,3]

The criticality of the two limitations are noted by Koch, et al.,[1] who found that complex terrain not only contributes to alterations in airflow, but also to increased amounts of turbulent diffusion compared with flat terrain. This increased turbulence is attributed primarily to drainage flow and lee waves, two factors noted above that MPF-TD does not consider very well. Drainage flow as a major turbulence mechanism is very important, especially near the surface on a mountain slope in a very stable atmosphere. These two critical limitations of MPF-TD led to the disapproval by EPA for its use at the McGill Smelter.

6.2 MODEL EVALUATIONS

Review of MPF-TD has been rather limited since it has, until recently, remained a proprietary model of INTERA, Inc. Review has generally been coincidental with review of other complex terrain models, and in this context MPF-TD compares very well in accuracy with current Gaussian techniques. Probably of considerable importance is that MPF-TD calculates a good approximation of the velocity fields on the upwind side of obstacles. This description of the windflow in complex terrain is thought to provide a much closer simulation of physical reality than typical Gaussian models, even though recirculating and convective flow treatment is neglected.

Comments in literature and recent reports are both supportive and critical of MPF-TD. Battelle Laboratories reported to the Electric Power Research Institute[5] that the MPF-TD Model produced ground-level concentration estimates reasonably close to field data collected near the Navajo Generating Station in Northern Arizona.[6] In a report to the EPA, Geomet Incorporated[1] commented that the MPF-TD Model appeared to make estimates to within about a factor of two or three of measured concentrations. The model systematically overestimates concentrations with respect to plume centerline in the first 4 to 5 km near the plant in complex terrain. Geomet concluded from a survey of the literature and recent field studies that neither the Valley Model or the MPF-TD Model adequately take into account the initial dilution resulting from emission-related parameters (buoyancy and turbulence generated

by stack exit velocity and temperature). A copper smelter may not generate the same volume or temperature of gas as a power plant, however, and so the results here should be kept in the context of the smelter stack. A major feature of the Geomet report is the similarity of estimates between Valley and MPF-TD.

INTERA, Inc., was contracted by EPA to review their own MPF-TD Model as well as other complex terrain models in the context of several sets of monitor results from field studies in complex terrain.[3] INTERA and EPA did not agree on the interpretation of MPF-TD results. Basically, INTERA maintains that MPF-TD yields good estimates in complex terrain even though recirculating and convective flows are not treated. The EPA, on the other hand, disagrees with the overall interpretation of results and the validity of some inputs. The disagreement stems from the definition differences of "reliable estimate." The EPA contends that a reliable estimate must represent the near upper envelope of observed concentrations (i.e., the upper few percentile). INTERA interprets a reliable estimate as one that best fits an average of observed data. Thus, conclusions of this report[3] are that MPF-TD performs well for the criteria established by INTERA, but is not necessarily accepted by EPA.

Finally, in an unpublished paper presented by INTERA, Inc., on behalf of Kennecott,[4] MPF-TD is found to estimate concentrations to within about a factor of two. INTERA further recommended additional physical modeling or field studies to determine more realistic values for each of the MPF-TD empirical parameters.

6.3 APPLICATIONS TO McGILL

Previous applications of the MPF-TD Model to McGill include a 1972 application to SO_2 emissions from the then proposed 229-m main stack and the 104-m acid plant stack. The results of this modeling indicated that SO_2 concentrations greater than 328 $\mu g/m^3$ occur with a frequency of 7.8 percent or 28 days a year.[7] The maximum concentration of 2077 $\mu g/m^3$ occurred about 1.5 km to the southeast of the plant at a receptor elevation near the 7800-ft level. No violations attributable to the stacks on an annual average were found.

In an August 7, 1979, presentation to EPA, the MPF-TD SO_2 results from 1972 were prorated for TSP by dividing by the SO_2 emissions and multiplying by the TSP emissions. The maximum estimated annual concentration and the maximum 24-hour concentrations were 2.7 and 124 $\mu g/m^3$, respectively. Although documentation for the MPF-TD Model is adequate to evaluate its applicability and reasonableness for modeling the Kennecott McGill Copper Smelter, documentation for the McGill application itself is rather sparse. Little indication is given in the Kennecott comments, responses, technical papers, or presentations of the source parameters, receptor grid, or meteorological data used. Input data probably included data similar to that in other model applications at McGill (Valley and AQDM).

6.4 SUMMARY AND CONCLUSIONS

The MPF-TD Model is a potential flow model modified to consider the effects of complex terrain and to include pollutant

dispersion. Two theoretical limitations of MPF-TD are that it does not consider recirculating flows (i.e., in the lee of complex terrain), and it does not allow the formation of convective flows (e.g., mountain drainage winds). These two limitations as well as the fact that MPF-TD does not estimate the worst case concentrations on terrain form the major basis for EPA's objection to using MPF-TD. The model has been compared with monitored pollutant concentrations and has been shown to give agreement to within a factor of ± 2. Documentation, however, for actual past applications is rather sketchy and cannot be adequately scrutinized. More recent applications and comparisons with other modeling techniques and monitor values at McGill are necessary to yield a clearer picture of the appropriateness of the MPF-TD Model for application to the smelter. Also the level of application deemed appropriate must be considered along with the treatment of physical parameters and resultant concentrations. Though the simulation of real wind flows, etc., is somewhat better in the MPF-TD Model than a more simplified technique, the limitations noted above should be heeded in interpreting results. Thus, the use of the MPF-TD Model for McGill may be appropriate with better documentation to meet EPA objections, but the results at this time are unacceptable to EPA.

REFERENCES FOR SECTION 6

1. Koch, R. C., et al. Power Plant Stack Plumes in Complex Terrain. EPA-600/7-77-020, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. 1977.

2. Hoffnagle, G. F., V. A. Mirabella, and T. C. Spangler. Model Simulation of a Tracer Study in Rough Terrain. First Conference on Regional and Mesoscale Modeling, Analysis, and Prediction. Las Vegas, Nevada, May 5-9, 1975.

3. INTERCOMP Resources Development and Engineering, Inc. Evaluation of Selected Air Pollution Dispersion Models Applicable to Complex Terrain. EPA-450/3-75-059, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. 1975.

4. Halitsky, J., et al. Validation Studies of a Modified Potential Flow Model for Dispersion in Complex Terrain Submittal and Summary of Comments of Kennecott Copper Corporation. Unpublished. September 21, 1979.

5. Drake, R. L., D. J. McNaughton, and C. Huarg. Mathematic Models for Atmospheric Pollutants, Appendix D: Available Air Quality Models. EA-1131 Appendix D, Electric Power Research Institute, Palo Alto, California. 1979.

6. Lantz, R. B., G. F. Hoffnagle, and V. A. Mirabella. Comparison of Several Models with Ambient Sulfur Dioxide Measurements Near the Navajo Generating Station. Presented at 69th Annual Meeting of the Air Pollution Control Association, Portland, Oregon. June 27-July 1, 1976. Paper No. 76-34.2.

7. Templeton, F. E., et al. Sulfur Dioxide Concentrations Resulting From Air Quality Control Programs at Kennecott's Smelters. Unpublished. Kennecott Copper Corporation. October 13, 1972.

SECTION 7

STATISTICAL ANALYSIS OF AIR MONITORING DATA

Since 1972, measurements of the 24-hour concentrations of TSP have been made at various times at five monitoring sites located near the McGill Smelter (see Figure 1-1). Two of these sites, the State-operated McGill School site and the Kennecott Townsite, are located in McGill less than 1.5 km from the smelter plant. Two other sites operated by Kennecott, North Flat and Gallagher Gap, are located about 5.0 and 6.0 km, respectively, to the north of the plant. Kennecott's other site, the South Flat site, is located 4 km south-southwest of the smelter. Measurements of general windflows in the Steptoe Valley, which were derived from meteorological data gathered at the Ely Airport and North Flat site, indicate that prevailing winds follow the basic north-northeast to south-southwest alignment of the valley. Thus, the monitors are located where they can take full advantage of the frequent winds from the direction of the various sources of particulates.

The EPA analyzed TSP air quality monitoring data collected at the McGill School site to determine if the main smelter stack at the McGill Smelter is contributing significantly to violations of the 24-hour TSP NAAQS. PEDCo has presented this independent

appraisal of air quality data gathered at the McGill School and other sites to substantiate this determination.

7.1 CUMULATIVE FREQUENCY DISTRIBUTIONS

From August 1976 to May 1979, a total of 158 24-hour TSP measurements were collected at the McGill School site. Of this total, 118 measurements were made on days when the smelter was in operation, and 37 were made on days when the smelter was not in operation. The EPA analysts constructed cumulative frequency distributions of the TSP data when the smelter was operating and when it was not operating (see Figure 7-1). It is evident from the cumulative frequency distributions that TSP concentrations were higher when the smelter was in operation than when it was not in operation. When the smelter was operating, both the primary and secondary TSP standards were exceeded; when the smelter was not operating, only the secondary TSP standard was exceeded.

PEDCo assembled a slightly larger collection of TSP measurements from the McGill School site (263 samples were collected from January 1975 to December 1979) and constructed a similar analysis of the samples. As can be seen in Figure 7-2, very little difference arose from the expanded data set. Both sets of data (Figures 7-1 and 7-2) exhibit higher measured TSP concentrations when the smelter is operating than when it is not operating. This fact alone, however, is not sufficient evidence to

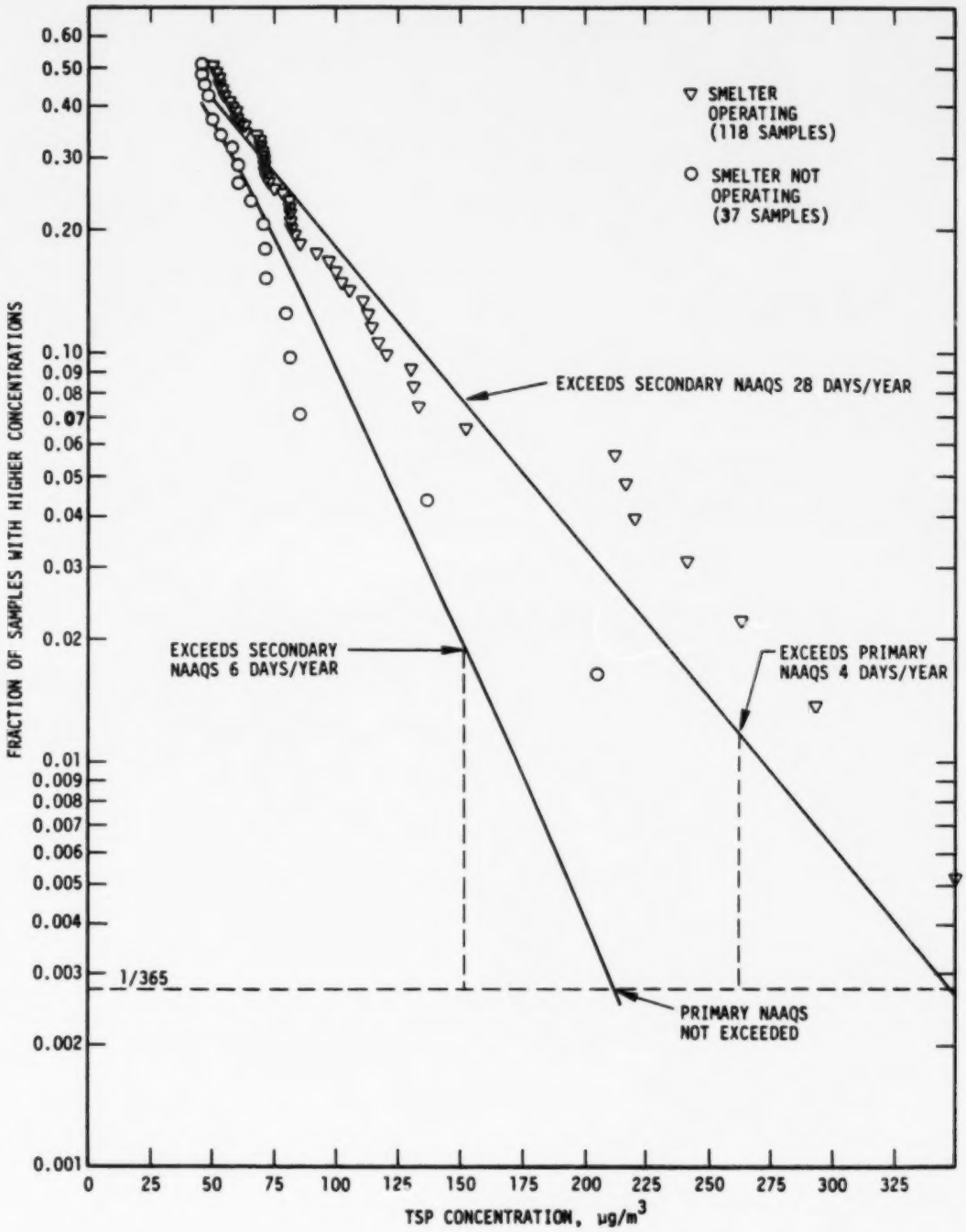

Figure 7-1. TSP cumulative frequency distributions for the McGill School Monitor: 8/76 to 5/79 (smelter operating vs smelter not operating).

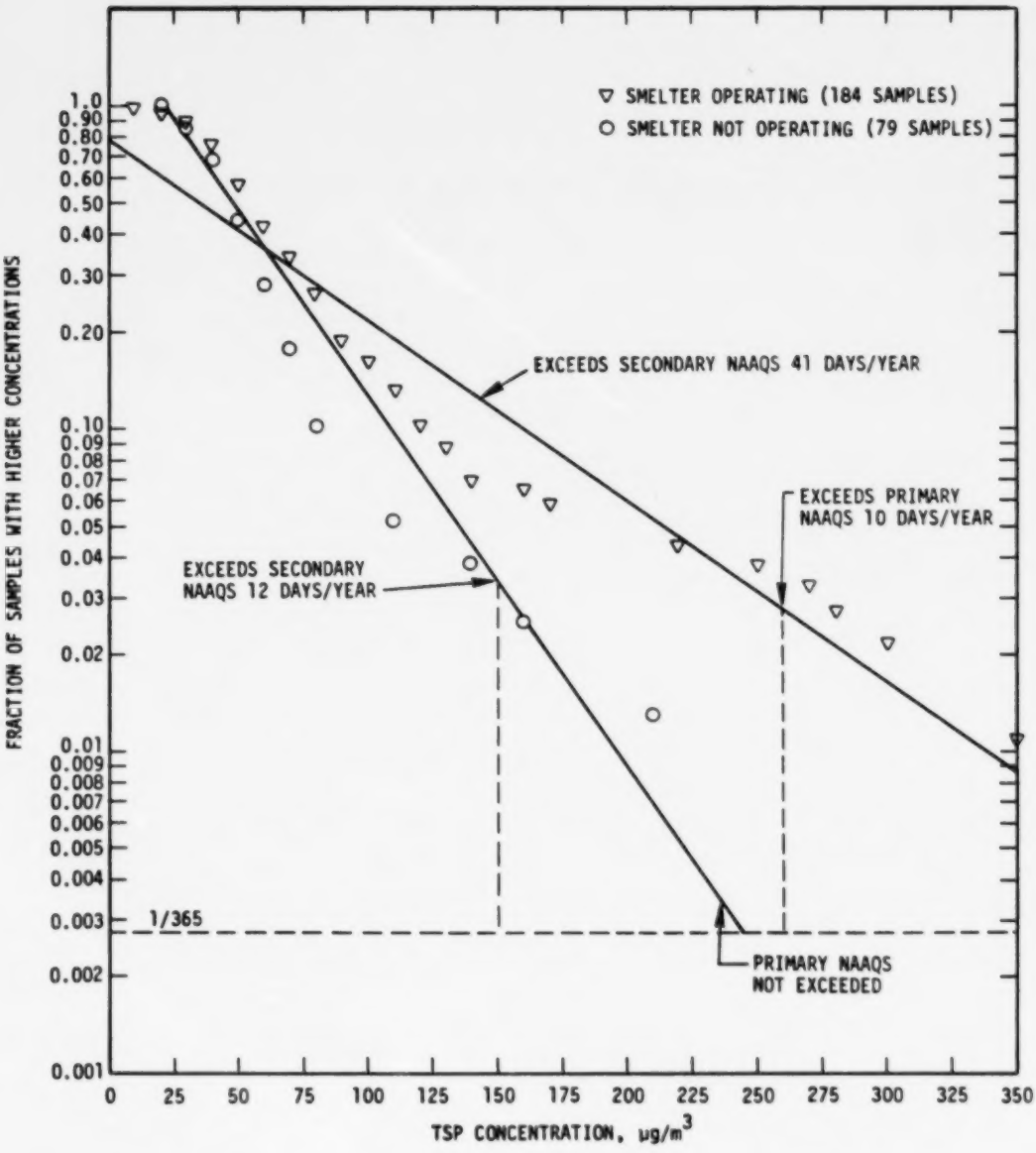

Figure 7-2. TSP cumulative frequency distributions for the McGill School Monitor: 1975 to 1979
(smelter operating vs smelter not operating).

support the conclusion that the main stack at the smelter is the major contributor to these violations. Previous modeling and state-of-the-art dispersion techniques indicate that emissions from the main stack had a small impact at the McGill School monitor. Thus, higher measured TSP concentrations may occur when the plant is operational, but increased activity at other smelter-related sources may contribute significantly more particulates to the McGill School site.

In order to fully examine the available monitoring data, cumulative frequency distributions of TSP concentrations measured at other nearby monitoring sites were also derived. Figures 7-3 through 7-5 present the distributions for the North Flat, the Townsite, and the South Flat sites, respectively. With the exception of Figure 7-5 (South Flat), these figures show that TSP concentrations tend to be higher when the smelter is in operation. The South Flat (Figure 7-5) shows lower concentrations when the smelter is in operation.

Though no joint frequency distribution of wind direction, smelter operation, and TSP concentrations was derived, the wind rose shown in Figure 2-1 indicates a predominance of winds from the south and south-southwest. Thus, the North Flat monitor to the north of the plant has concentrations higher than the South Flat monitor. The McGill School site and the Townsite, which lie just to the south of the smelter and to the east of the tailings, may be affected by any number of increased emissions when the smelter is operational, regardless of wind direction. Table 7-1,

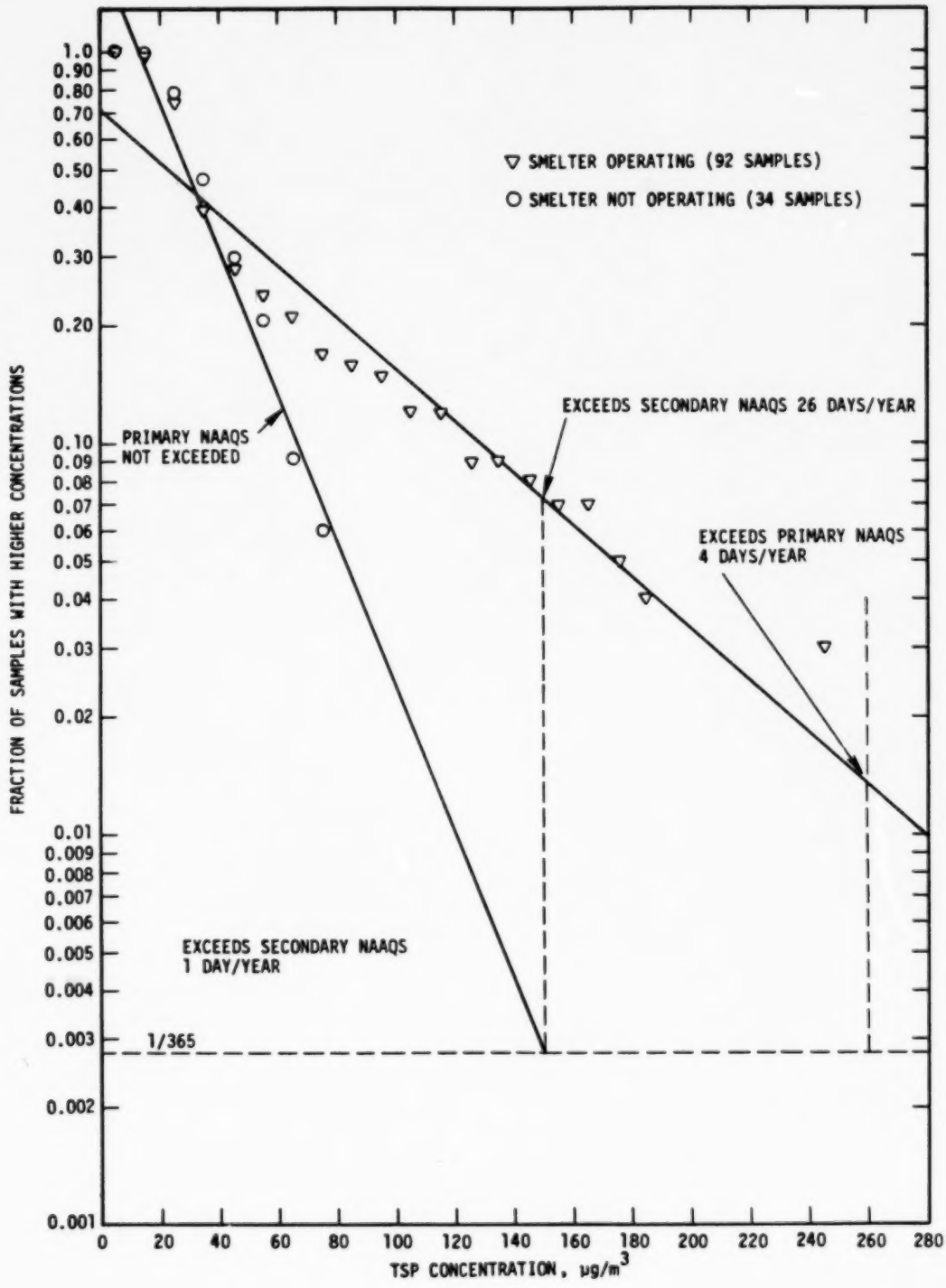

Figure 7-3. TSP cumulative frequency distributions for the North Flat Monitor: 11/77 to 12/79
(smelter operating vs smelter down).

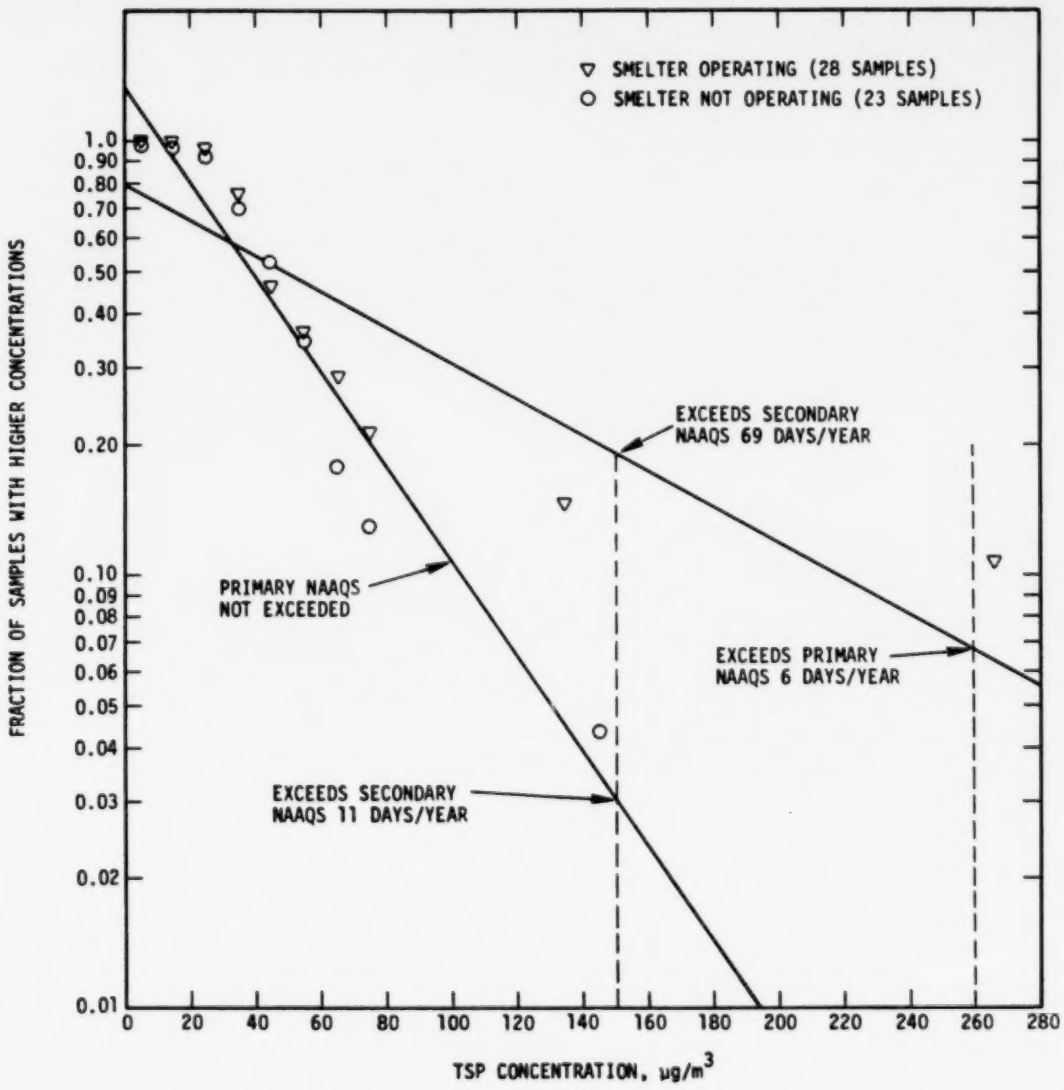

Figure 7-4. TSP cumulative frequency distributions for the Townsite Monitor: 11/77 to 12/5
(smelter operating vs smelter not operating).

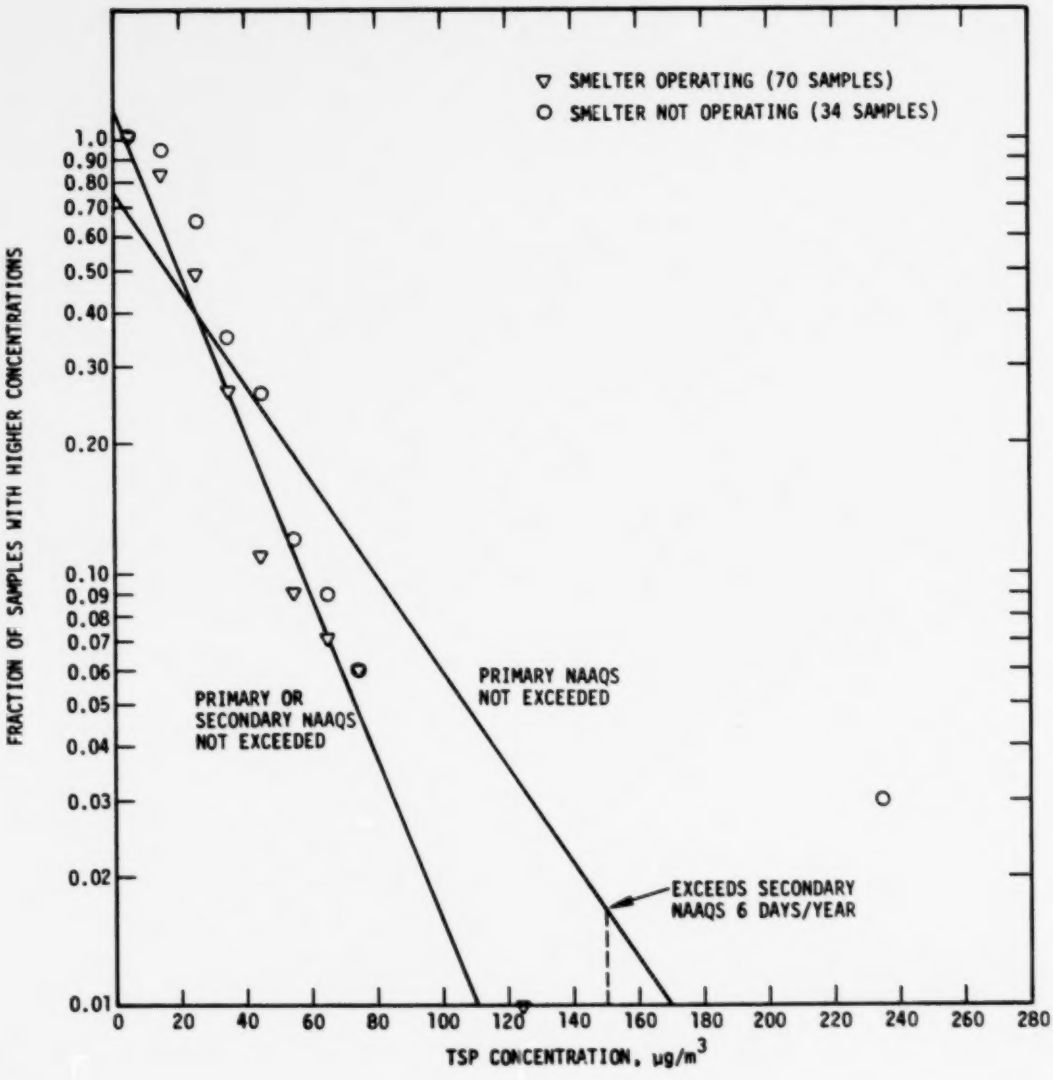

Figure 7-5. TSP cumulative frequency distributions for the South Flat Monitor: 11/77 to 12/79
(smelter operating vs smelter not operating).

TABLE 7-1. SUMMARY OF 24-HOUR CONCENTRATIONS OF TSP FOR MONITORS LOCATED NEAR THE MCGILL SMELTER

Monitoring site	Year	Smelter operating				Smelter not operating			
		Concentration, $\mu g/m^3$				Concentration, $\mu g/m^3$			
		Number of observations	Min.	Max.	2nd max.	Number of observations	Min.	Max.	2nd max.
McGill School	1975	40	25	1078	478	13	20	332	82
	1976	26	15	358	271	28	22	151	84
	1977	50	7	351	291	7	21	72	54
	1978	49	15	262	215	3	33	79	42
	1979	19	17	88	79	28	19	203	135
North Flat	1977	10	11	585	238	0			
	1978	58	4	543	340	3	25	62	33
	1979	27	8	265	119	32	11	79	73
South Flat	1977	1		19		0			
	1978	43	2	120	74	2	57	80	
	1979	29	5	82	71	31	5	234	62
Gallegher Gap	1978	14	15	302	182	0			
Townsite	1977	9	25	872	453	0			
	1979	19	21	621	73	23	9	145	72

which was derived from the same data set as the one used in the distributions, indicates higher TSP concentrations when the smelter is operational than when it is nonoperational. The highest concentrations occurred at the McGill School, North Flat, and Townsite locations. This was expected based on a review of the relative source-receptor locations, the major particulate emitters, and the distribution of winds.

Figures 7-1 through 7-5 indicate the number of days that may exceed the standards for TSP in a year. The actual number of violations (shown in Table 7-2), however, are much lower than those estimated in the figures. Ambient air samples are only taken every sixth day; therefore, the actual number of violations measured would be expected to be much lower. To interpret the expected exceedances in terms of the current monitoring schedule, the values in the figures must be reduced by a factor of six.

The conclusion that may be made regarding this analysis is that TSP concentrations are higher when the smelter is operational than when it is nonoperational. There is no evidence, however, which clearly indicates that the higher TSP concentrations are only due to emissions from the main stack. However, the North Flat monitor is near an expected maximum impact point (via modeling) and shows more change of violation when the smelter is operating. Further differentiation of stack versus other particulate sources must be made to assess various contributions to measured TSP concentrations (e.g., tracer studies or particulate identification).

TABLE 7-2. SUMMARY OF VIOLATIONS OF THE 24-HOUR NAAQS FOR TSP AS MEASURED AT MONITOR SITES LOCATED NEAR THE KENNECOTT SMELTER AT MCGILL, NEVADA

Monitor site	Period of record	Number of violations of NAAQS		
		Primary	Secondary	Total
McGill School	1/1/75 to 12/29/79	9	16	16
North Flat	11/3/77 to 12/29/79	4	7	7
South Flat	11/3/77 to 12/29/79	0	1	1
Gallegher Gap	7/13/78 to 9/29/79	1	2	2
Townsite	11/3/77 to 12/27/77 and 4/27/79 to 12/29/79	3	3	3
Total		17	29	29

7.2 WIND DIRECTION VS VIOLATIONS

Descriptions of the 24-hour average wind directions for each day a violation occurred may yield a clearer interpretation of potential contributing sources. Figure 7-6 shows a map of the McGill area and each monitoring site. Shown at each monitoring site are an array of arrows indicating the resultant wind directions (derived from observations made at the Ely Airport) associated with each excursion of the NAAQS from 1976 to 1979. The length of the arrow indicates the number of violations from that direction, and each direction includes up to $\pm$22.5 degrees of horizontal angle. The predominant feature of this figure is that the McGill School and Townsite locations are affected by a variety of wind directions, which indicates the influence of fugitive particulate emissions at the smelter and from the tailings. The North Flat site, however, is mostly influenced by the winds from the south-southwest, which is in the vicinity of nearly all of the particulate emissions. Thus, on a 24-hour basis there are no clearcut indications of any particulate source differentiation.

Further analyses of these violations using hourly meteorological data rather than 24-hour averages may better indicate the dependence of high TSP values on wind direction and windspeed. Since atmospheric conditions rarely persist for 24 hours, the analysis shown in Figure 7-6 represents only average conditions and does not represent short-term influencing events. Thus, this analysis yields only a limited interpretation of the most influential wind directions.

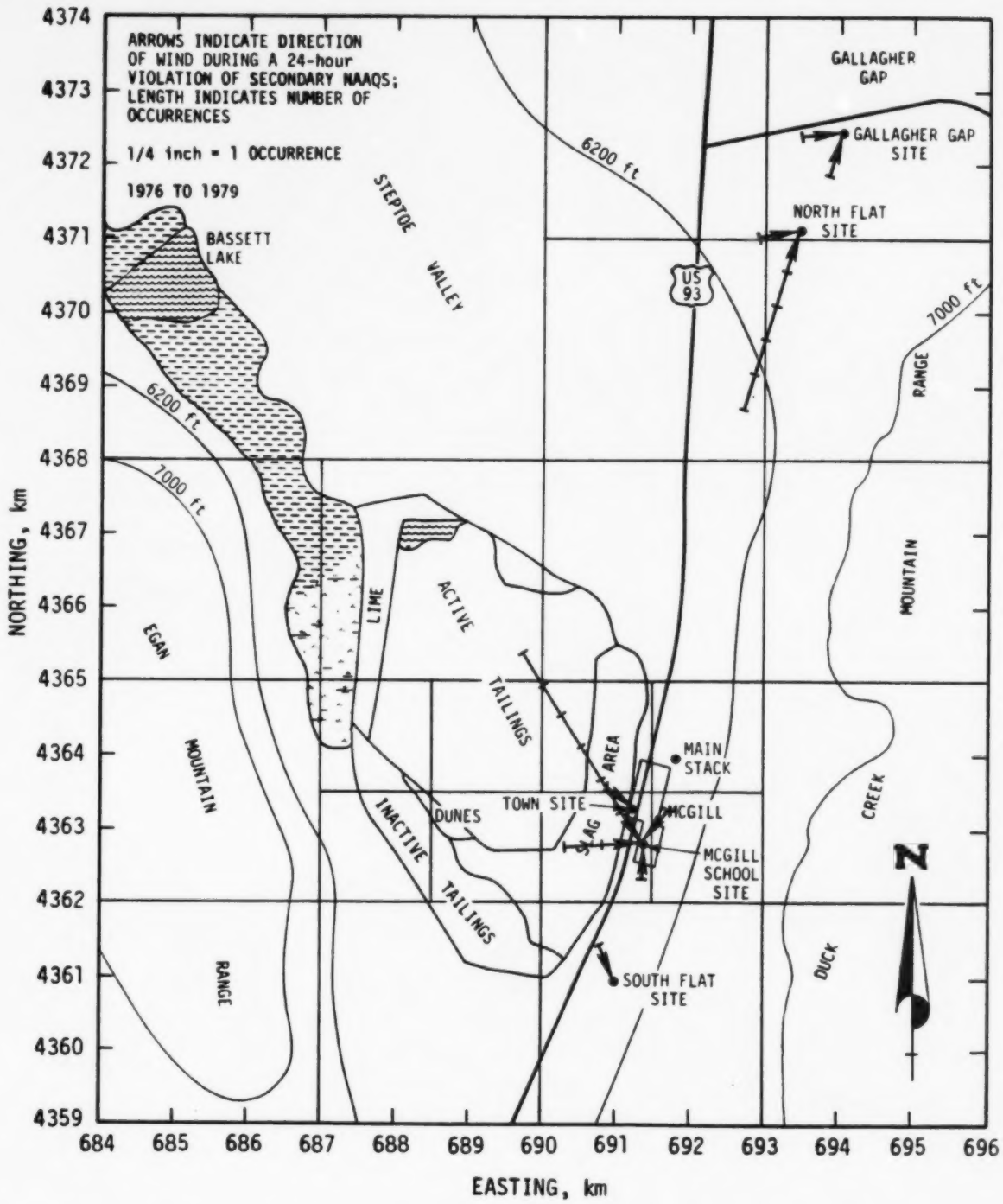

Figure 7-6. Map showing resultant wind directions associated with each excursion of the NAAQS from 1976 to 1979.

7.3 SUMMARY

The reanalysis of the cumulative frequency distribution of TSP for all monitor sites near the McGill Smelter and attempts to relate TSP concentrations to potential sources have led to the conclusion that TSP concentrations are higher when the plant is operational. Insufficient evidence, however, is available to differentiate the main stack as the major contributor to these increased concentrations. When viewed in light of the modeling analyses, the monitor by monitor evidence suggests that the Townsite and McGill School site are influenced by the smelter fugitives, and the North Flat site by the main stack.

SECTION 8

CONCLUSIONS

Limited conclusions may be drawn from the independent review and analysis of the McGill Smelter performed by PEDCo Environmental. Sufficient evidence to differentiate between air quality impacts of the main stack and other sources of particulate emissions is lacking. Particulate controls for the main stack, the tailings pond, and fugitive smelter process emissions should be considered until the interaction of all sources and the impact at various source locations are better understood.

This review yielded several interpretations of the ambient TSP concentrations and source-receptor relationships. The dispersion modeling indicated that high concentrations on the eastern mountains were primarily due to emissions from the main stack. However, only very limited monitoring of TSP on the terrain has taken place and thus cannot really be used to verify these high estimated concentrations. Comparisons of concentrations at several monitors indicate higher measured TSP when the plant is operational. No data adequately support the hypothesis that the main stack contributes significantly to measured TSP levels, although they are higher when the smelter is operational. However, at the North Flat site a combination of modeling and monitoring analyses seem to indicate that the main stack may be

the main contributor to TSP concentrations. Based on the same analyses, fugitive smelter emissions when the plant is operational appear to contribute to monitors closer to the plant, i.e., the Townsite and the McGill School monitors). The monitor cannot differentiate sources.

Thus, EPA is correct in concluding from modeling and monitoring results that the McGill Smelter contributes significantly to ambient TSP levels. Actual control levels for particulate sources must be based on modeling and monitoring results that consider source contribution adequately.